LAKESHORE CAPACITY STUDY

WILDLIFE

LAKESHORE CAPACITY STUDY

WILDLIFE

MARCH 1983

Prepared by:
D.L. EULER, B.A., M.A.T., Ph.D.
Ministry of Natural Resources

For:
Ministry of
Municipal Affairs and Housing

Ministry of
Municipal
Affairs
Ontario

The following Lakeshore Capacity Study reports

Committee Report
Land Use
Fisheries
Microbiology
Trophic Status
Wildlife
Integration

are available from:
Ontario Government Bookstore
880 Bay Street, Toronto M7A 1N8

Telephone (416)965-6015
Toll free 1-800-268-7540
In area code 807 dial 0-Zenith 67200

Questions should be addressed to:
Ministry of Municipal Affairs
Research and Special Projects Branch
777 Bay Street, 13th Floor
Toronto, Ontario M5G 2E5

Printed by the Queen's Printer for Ontario
ISBN 0 7743 8078 0

Lakeshore Capacity Study Steering Committee

Ministry of Municipal Affairs and Housing

M.H. Sinclair Chairman
J.C. Downing

Ministry of the Environment

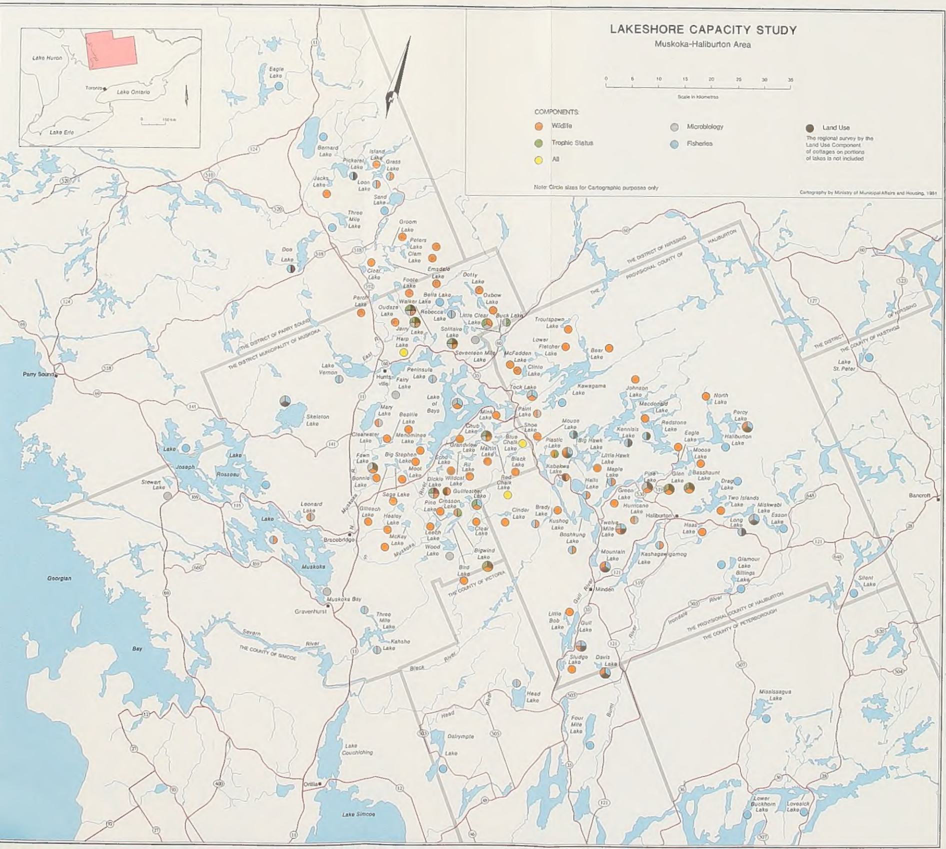
S.E. Salbach

Ministry of Natural Resources

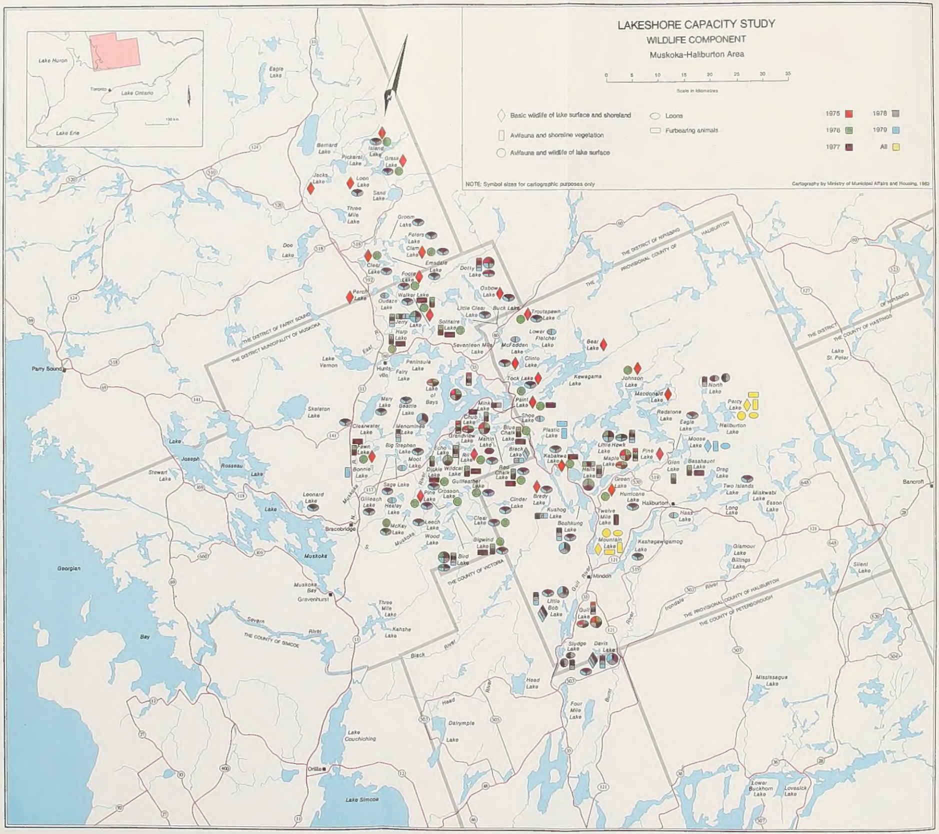
R.A. Riley

Study Coordinator

G.C. Teleki DeLeuw Cather, Canada Ltd. (DeLCan)



LAKESHORE CAPACITY STUDY
Muskoka-Haliburton Area
0 5 10 15 20 25 30 35
Scale in Kilometres
COMPONENTS
Wildlife
Trophic Status
All
Microbiology
Fisheries
Land Use
The regional survey by the Land Use Component of cottages on portions of lakes is not included
Note: Circle sizes for Cartographic purposes only
Cartography by Ministry of Municipal Affairs and Housing, 1981
Lake Huron
Toronto
Lake Ontario
Lake Erie
Eagle Lake
Bernard Lake
Island Lake
Pickerel Lake
Grass Lake
Jacks Lake
Loon Lake
Sand Lake
Three Mile Lake
Groom Lake
Peters Lake
Clam Lake
Doe Lake
Clear Lake
Emsdale Lake
Dotty Lake
Foote Lake
Bella Lake
Oxbow Lake
Perch Lake
Walker Lake
Oudaze Lake
Rebecca Lake
Little Clear Lake
Buck Lake
Trout Lake
Jerry Lake
Solitaire Lake
Harp Lake
Seventeen Mile Lake
Lower Fletcher Lake
Bear Lake
McFadden Lake
Clinto Lake
Lake Vernon
Huntsville
Peninsula Lake
Fairy Lake
Tock Lake
Kawagama Lake
Johnson Lake
North Lake
Lake of Bays
Mary Lake
Beattie Lake
Mink Lake
Paint Lake
Macdonald Lake
Percy Lake
Skeleton Lake
Chub Lake
Shoe Lake
Mouse Lake
Redstone Lake
Clearwater Lake
Menominee Lake
Kennisis Lake
Eagle Lake
Haliburton Lake
Blue Chalk Lake
Plastic Lake
Big Hawk Lake
Moose Lake
Grandview Lake
Martin Lake
Little Hawk Lake
Fawn Lake
Big Stephen Lake
Echo Lake
Black Lake
Kabakwa Lake
Maple Lake
Basshaunt Lake
Moot Lake
Rill Lake
Halls Lake
Pine Lake
Glen Lake
Drag Lake
Bonnie Lake
Dickie Lake
Wildcat Lake
Red Chalk Lake
Green Lake
Two Islands Lake
Lake Joseph
Lake Rosseau
Stewart Lake
Sage Lake
Gullfeather Lake
Hurricane Lake
Miskwabi Lake
Leonard Lake
Gilleach Lake
Pine Lake
Crosson Lake
Cinder Lake
Brady Lake
Kushog Lake
Haliburton
Esson Lake
Long Lake
Healey Lake
Leech Lake
Clear Lake
Twelve Mile Lake
Haas Lake
Bancroft
Lake Muskoka
Bracebridge
McKay Lake
Wood Lake
Boshkung Lake
Bigwind Lake
Mountain Lake
Kashagawigamog Lake
Glamour Lake
Billings Lake
Georgian Bay
Parry Sound
Muskoka Bay
Bird Lake
Minden
Silent Lake
Gravenhurst
Three Mile Lake
Little Bob Lake
Gull Lake
Kahshe Lake
Sludge Lake
Davis Lake
Head Lake
Mississagua Lake
Four Mile Lake
Dalrymple Lake
Lake Couchiching
Orillia
Lake Simcoe
Lower Buckhorn Lake
Lovesick Lake
Lake St. Peter
Severn River
Black River
Gull River
Irondale River
Burnt River
Head River
THE DISTRICT OF PARRY SOUND
THE DISTRICT MUNICIPALITY OF MUSKOKA
THE DISTRICT OF NIPISSING
THE PROVISIONAL COUNTY OF HALIBURTON
THE COUNTY OF HASTINGS
THE COUNTY OF VICTORIA
THE COUNTY OF PETERBOROUGH
THE COUNTY OF SIMCOE



LAKESHORE CAPACITY STUDY
WILDLIFE COMPONENT
Muskoka-Haliburton Area
0 5 10 15 20 25 30 35
Scale in kilometres
Basic wildlife of lake surface and shoreland
Avifauna and shoreline vegetation
Avifauna and wildlife of lake surface
Loons
Furbearing animals
1975
1976
1977
1978
1979
All
NOTE: Symbol sizes for cartographic purposes only
Cartography by Ministry of Municipal Affairs and Housing, 1982
Lake Huron
Toronto
Lake Ontario
Lake Erie
Parry Sound
Huntsville
Bracebridge
Gravenhurst
Orillia
Minden
Haliburton
Bancroft
Georgian Bay
Lake Simcoe
Lake Couchiching
Lake Muskoka
Lake Joseph
Lake Rosseau
THE DISTRICT OF PARRY SOUND
THE DISTRICT MUNICIPALITY OF MUSKOKA
THE DISTRICT OF NIPISSING
THE PROVISIONAL COUNTY OF HALIBURTON
THE COUNTY OF VICTORIA
THE COUNTY OF SIMCOE
THE COUNTY OF PETERBOROUGH
THE COUNTY OF HASTINGS

FOREWORD

The Lakeshore Capacity Study was undertaken to provide a planning tool to assist in managing the development of Ontario's inland lakes. Basic to this task was the need to develop an improved understanding of the relationships between cottage development on the lakeshore and selected aspects of the environment. To accomplish these objectives the Ministry of Municipal Affairs and Housing, responsible for the Study, worked with the ministries of the Environment and Natural Resources.

The Muskoka-Haliburton area of central Ontario was chosen as the study area. This area lies within one physiographic region, part of the Precambrian shield, with similar soils and plant communities. The homogeneity reduced the need to account for major natural variations among the lakes and watersheds. Further, the extent of existing development on the lakes varied; permitting an examination of situations extending from no development to "full" development.

The Study involved measurement of the source of the environmental impact, the cottages and their use, and how development affects the indicators of impact: nutrient enrichment; public health; fish, angling and littoral zone; and wildlife and habitat modification. The research findings were linked in a simulation model. The model can predict trends for the various impacts on the watershed.

The Wildlife report examines the effect of shoreline habitat removal on several different animal communities. These communities are used as indicators of the wildlife population. The major achievement has been the development of quantitative methods for relating wildlife habitat losses associated with cottages to actual impact on the wildlife population.

The research has been documented in two volumes. The Wildlife volume contains the major findings regarding wildlife species and habitat and their responses to cottage development. Also, the wildlife model LAKELIFE is described. The Technical Report volume contains twelve background studies.

The objective of this phase of the Lakeshore Capacity Study, to develop a practical planning tool for lake-watershed management, has been achieved. The next step is further testing prior to implementation.

M.H. Sinclair
Chairman
Lakeshore Capacity Study

ACKNOWLEDGEMENTS

Without the dedication and willingness to work hard, shown by the people who conducted the data collection, this study would not have been possible. They are, in alphabetical order;

J. Adams
E. Armson
E. Armstrong (Supervisor, Author)
J. Barr (Author)
S. Bullock
M. Cadman
K. Clark (Author)
T. Clark (Supervisor, Author)
C. Cooper
R. Daniel
J. Dawson
L. Dix
S. Fast
R. Grant
M. Heimberger (Supervisor, Author)
T. Kellar (Supervisor)
C. Ketchum (Editor)
M. MacAnally
D. McAvoy
B. Martin
J. McDonnell (Author)
D. McNicol
D. Mojzes
J. Peterson
R. Phillips (Supervisor)
G. Racey (Supervisor, Author)
B. Ratcliff
K. Reyno (Editor)
L. Ruple
M. Sobchuck
M. Stoll (Editor)
M. Strathern
V. Woodhouse

G.D. Racey, T.P. Clark, J.A. McDonnell, the authors of Wildlife Part II would like to thank E. Armstrong, K. Clark, J. Harker, and M. Heimberger who did portions of the research upon which LAKELIFE is based, R. Everitt of ESSA Consultants who provided valuable criticism and programming expertise, S.E. Fast and M.E. Stoll who participated in the final preparation of model and manual.

During the last part of the study, after the others had gone, T. Clark and J. McDonnell (with M. Stoll and S. Fast) worked with skill and professionalism to bring various parts of the study together. Their dedication is highly appreciated.

David Euler, Manager
Wildlife Component

PEER REVIEW

This report was reviewed by the following panel of specialists for the author and the Study Steering Committee.

Mr. J.R. Bryant	Wildlife Science	Canadian Wildlife Service Ottawa, Ontario	1981
Dr. F. Gilbert	Wildlife Science	University of Guelph Guelph, Ontario	1977, 1981
Mr. J. Livingston	Environmental Ecologist	York University Downsview, Ontario	1977, 1981
Dr. J. Richardson	Wildlife and Statistics	L.G.L. Ltd. Toronto, Ontario	1981

TABLE OF CONTENTS

LIST OF FIGURES

PART I

PART II

LIST OF TABLES

PART I

PART II

PART I

INFLUENCE OF COTTAGE DEVELOPMENT AND USE ON WILDLIFE AND WILDLIFE HABITAT

1. INTRODUCTION TO THE WILDLIFE COMPONENT

1.1 BACKGROUND

The Lakeshore Capacity Study (LCS) was undertaken to determine the ability of land/lake ecosystems in central Ontario to support cottage development. The Study was intended to provide a comprehensive management tool and supporting scientific research for the use of provincial and municipal planners in their review of subdivision plans, development of official plans and in the decision-making process regarding cottage development in Ontario.

The Muskoka-Haliburton area in central Ontario was chosen as the area in which to concentrate investigation and research. It was intended, though, that the results of the Study and its management tool, a computer model, could be modified to evaluate the impacts of cottage development throughout the Province.

The Study was subdivided into areas of investigation or components. Each was examined by a team of researchers from an appropriate ministry of the Government of Ontario:

Land-use (Ministry of Municipal Affairs and Housing)
Microbiology (Ministry of the Environment)
Trophic Status (Ministry of the Environment)
Littoral Zone (Ministry of Natural Resources)
Fisheries (Ministry of Natural Resources)
Wildlife (Ministry of Natural Resources)

This report is a comprehensive synopsis and synthesis of the research of the Wildlife Component. It provides guidelines with which to aid planners and other professionals in the evaluation of development proposals (Part I). It also outlines the use of the computer model, LAKELIFE, the management tool developed by this component. See Part II for more information. Ecologists and other scientists can find detailed technical information reproduced in the Wildlife Technical Report (W.T.R.).

1.2 THE SHORELINE WILDLIFE COMMUNITY

Wildlife populations in the Muskoka-Haliburton area include several species ranging from ruby-throated hummingbirds (*Archilochus colubris*) to eastern hemlock (*Tsuga canadensis*) and black bears (*Ursus americanus*). The animals and plants present in this area make up a wildlife community characterized by a network of interrelationships among all species (Fig. 1). It is a group of organisms linked together by their effects on one another and their responses to the environment they share (Whittaker 1975).

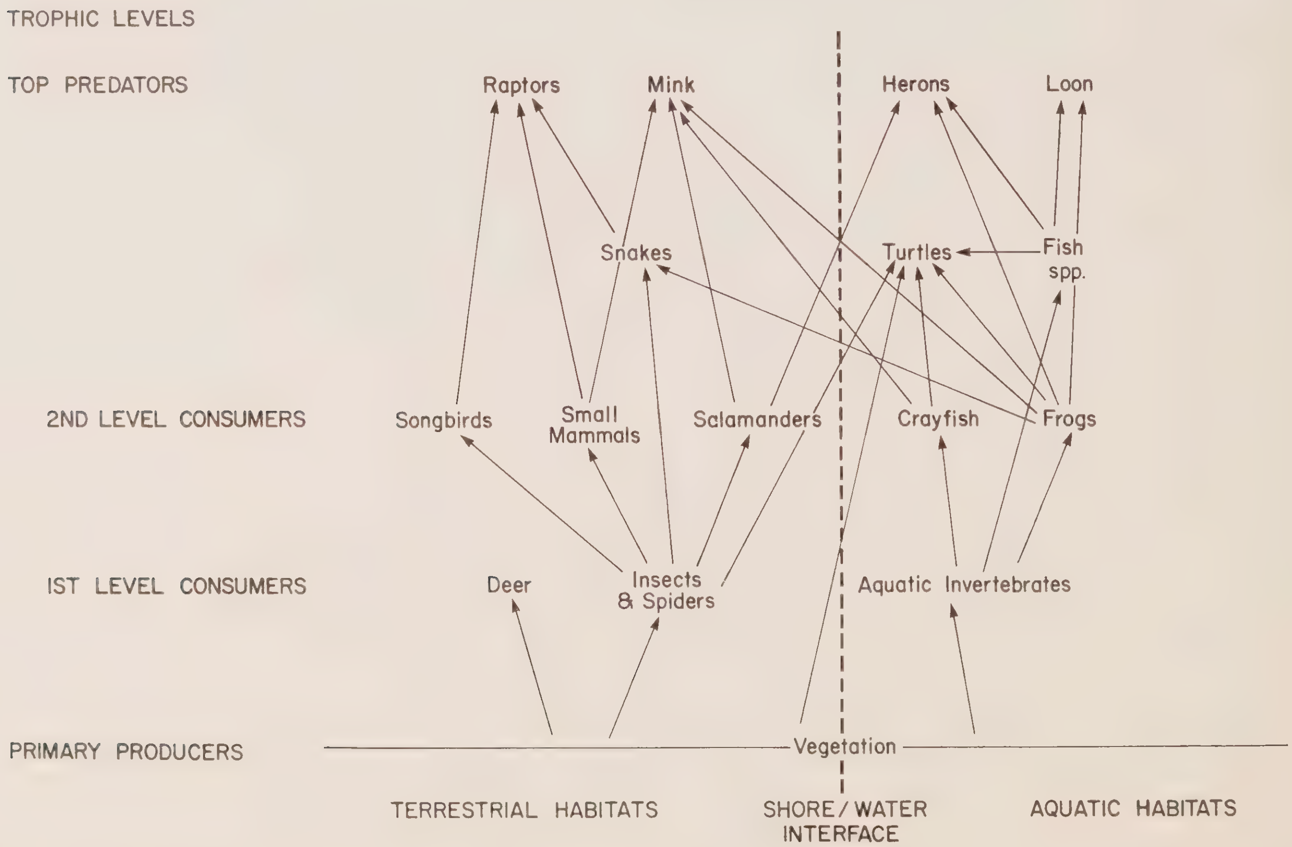


Figure 1. Diagrammatic representation of an ecological food web.

For the purpose of this Component, the shoreline communities are those within 100 m of the water. Shorelines provide a unique set of biophysical environmental features which significantly affect wildlife species when altered through cottage development. Since cottaging has been prominent in Muskoka-Haliburton for many years, we strove to provide information geared to protection of the interests of both human and wildlife communities.

In this report, wildlife refers to all species of non-domesticated, living organisms, including mammals, birds, reptiles, amphibians, and terrestrial vegetation but excluding humans, aquatic organisms, and invertebrates. Habitat refers to the kind of environment in which an animal or plant species is found, composed of both biological (the wildlife community) and non-biological components. From the wildlife community it was necessary to select certain species or groups of species for study. Research concentrated on songbirds, common loons, hawks, small mammals, mink, deer, reptiles, amphibians, and terrestrial vegetation. These were chosen because:

- they were present in sufficient numbers to study;
- they were representative of major components of the wildlife community; and
- they represented the wide range of values which people place on wildlife.

1.3 ASSUMPTIONS AND LIMITATIONS

Cottage development is defined as the construction of cottages and associated developments such as roads, transmission line corridors, boathouses, beaches, docks, and weirs. It was assumed that the most significant impact of cottage development on wildlife species is caused by the removal of trees, shrubs, and ground vegetation for cottage development. Cottagers usually clear portions of the shoreline for lawns, patios and beach areas. Vegetation in the littoral zone is also altered to facilitate boating and swimming. These development-related changes were studied extensively. Clearly, other cottager activities affect wildlife populations; however, it was not possible to make detailed investigations of these due to limitations of time and budget.

The research of this Component concentrated on ribbon shoreline development where a lake was ringed, partially or completely, by a single tier of cottage lots, each having its own shoreline frontage. Cluster cottage developments, private campgrounds, and trailer parks were not studied. However, the results, recommendations and even the computer model, (LAKELIFE), could still be applied to these situations with appropriate modifications.

The lakes chosen for study by this Component had a maximum of 10 km of shoreline. Since wildlife populations are often independent at greater distances, the recommendations and LAKELIFE will apply most directly and accurately to lakes in this size range. However, larger bodies of water can be divided into lake units containing less than 10 km of actual shoreline.

2. INTRODUCTION TO THE STUDY AREA

2.1 THE STUDY AREA

Muskoka-Haliburton lies within the Georgian Bay-Ottawa Valley physiographic region of Ontario where the bedrock of the Canadian Shield exerts a strong influence on the landscape (Chapman 1975) (Fig. 2). Ancient igneous and metamorphic rock formations have undergone extensive folding while exposed surfaces exhibit the results of long-term differential erosion. These processes have created numerous rock basins and troughs now occupied by swamps and lakes. About one-third of the region has a very thin layer of glacial till interspersed with large areas of exposed rock. The rest of the area is covered by varying depths of sandy, stony till.

Figure 2. A map of the Study area.

2.2 CLIMATE

The climate is cool and moderately moist. In the southern regions of the Study area, the mean annual temperature is 5.5°C, while in the Algonquin Park Highlands, it is 4.4°C. Although Georgian Bay tends to moderate the climate, resulting in a longer frost-free period annually in the western portion of the Study area, the Algonquin Highlands tend to sustain the opposite effect in the east. The town of Dorset, near the centre of this region, has an average of 107 frost-free days per year. Annual precipitation ranges from 104 cm on the western area facing Georgian Bay to 81 cm in the east (Atmospheric Environment Service, Environment Canada).

2.3 SOILS

There are three major soil associations (Chapman 1975):

1) predominantly coarsely textured soils with Precambrian rock at a depth of 1/3 m or less;
2) predominantly coarsely textured soils formed on sand or gravel; and,
3) predominantly finely textured soils formed on till or lacustrine sediments.

Most of the Muskoka-Haliburton region is forested. The land is not suitable for agriculture due primarily to the rock outcroppings and associated shallow soil, rough topography, and swamps. The few areas in which deep soil occurs usually have low crop productivity because the soil is sandy and highly acidic. Viable farms are primarily in drumlin areas overlying crystalline limestone bedrock.

2.4 VEGETATION

The vegetation characteristic of this area is the Great Lakes-St. Lawrence Tolerant Hardwood Forest (Rowe 1972). Eastern white pine *(Pinus strobus)*, red pine *(Pinus resinosa)*, eastern hemlock *(Tsuga canadensis)*, yellow birch *(Betula alleghaniensis)*, sugar maple *(Acer saccharum)*, red maple *(Acer rubrum)*, and red oak *(Quercus rubra)* are the major tree species. Basswood *(Tilia americana)*, large-toothed aspen *(Populus grandidentata)*, and eastern white cedar *(Thuja occidentalis)* are also common. To a lesser extent, beech *(Fagus grandifolia)*, white oak *(Quercus alba)*, butternut *(Juglans cinerea)*, and white ash *(Fraxinus americana)* are present. Intermixed with these are species more common to the Boreal Region of northern Ontario such as white spruce *(Picea glauca)*, black spruce *(Picea mariana)*, trembling aspen *(Populus tremuloides)*, balsam poplar *(Populus balsamifera)*, white birch *(Betula papyrifera)*, and balsam fir *(Abies balsamea)*.

3. COTTAGE IMPACT ON WILDLIFE AND HABITAT

3.1 DEVELOPMENT INDICES: ESTIMATES OF COTTAGE IMPACT

Before the impacts of cottage development on wildlife could be studied, a method was needed to quantify development. The first phase in this study was to develop several indices which measured cottage development. The second phase was to investigate how these changes affected wildlife.

The Area Development Index (ADI) used to measure the effects of cottage development on mink and small mammals was based on disturbance of vegetation in three layers; ground, shrub, and tree (Table 1; Fig. 3). This Index was calculated as follows:

$$ADI = (Ag + As + At)/AREA \qquad (1)$$

where Ag is the area disturbed (ha) in the ground layer
As is the area disturbed (ha) in the shrub layer
At is the area disturbed (ha) in the tree layer
AREA is the size (ha) of the cottage lot.

The cottage lot is the area legally defined as owned by a person or corporation. An area was considered disturbed if a building or other man-made object occupied it, or if human activity had halted natural succession and/or returned the area to an earlier successional stage. When the vegetation of a cottage lot or a sample plot was entirely disturbed, the ADI had a value of 3.0.

Table 1. Development indices used in LCS and their application.

Abbr.	Name	Definition	Application (Wildlife Technical Report Chapter)
ADI	Area Development Index	ADI=GDI+SDI+TDI	Mink (8) Small mammals (9) Habitat Disturbance (2) Vegetation (1)
GDI	Ground Development Index	Proportion of total area disturbed in ground vegetation layer	Songbirds (7) Habitat Disturbance (2)
SDI	Shrub Development Index	Proportion of total area disturbed in shrub vegetation layer	Habitat Disturbance (2)
TDI	Tree Development Index	Proportion of total area disturbed in tree vegetation layer	Habitat Disturbance (2)
CLDI	Cottager Loading Development Index	CLDI=log (CxU/AxD)	Mink (8)
LDI 150	Loon Development Index 150	No. of cottages within 150 m of nest	Loons (4)
LDI 250	Loon Development Index 250	No. of cottages within 250 m of nest	Loons (4)

One component of the ADI, the Ground Development Index (GDI), was used in the songbird study. This was derived from the formula:

$$GDI = Ag/AREA \qquad (2)$$

where Ag is the area disturbed (ha) in the ground layer.

This Index was useful for the prediction of songbird community composition (W.T.R.: 7), and was also used for the study of reptiles and amphibians (W.T.R.: 11).

An estimate of human disturbance, the Loon Development Index (LDI), was necessary to quantify the relationship between human activity around a nest and common loon reproductive success. This estimate was calculated as the number of cottages within a 150 m radius of the actual or potential nest (LDI 150) or as the number of cottages within 250 m (LDI 250) (W.T.R.: 4).

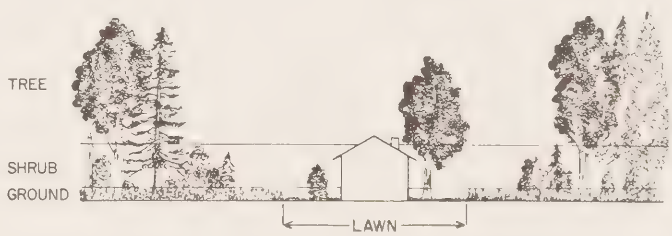


Figure 3. Schematic diagram of a cottage lot illustrating differential disturbance in the ground, shrub and tree layers.

The Cottager Loading Development Index (CLDI) was used to reflect both the intensity of human use of the lake surface and the distribution of cottages on its perimeter. The CLDI was given by:

$$CLDI = \log (C \times D/A \times U) \qquad (3)$$

where C = the number of cottages on the lake
U = the length of the undeveloped shoreline (m)
A = the surface area of the lake (ha)
D = the length of the developed shoreline (m).

This Index was a good indicator of the amount of mink activity on the lake (W.T.R.: 8). A low value of the CLDI indicated favourable conditions for mink; any value of the CLDI greater than 1.0 suggested that development pressures on the lake created conditions unfavourable for them.

All of these indices are discussed further in the following sections that deal with the effects of cottage development on wildlife and are used extensively by the computer model, LAKELIFE.

3.2 RELATIONSHIP BETWEEN THE AREA DEVELOPMENT INDEX AND COTTAGE LOT CHARACTERISTICS

Thirty-two developed lakes were selected at random in the Study area and lot size measured for 1,036 cottage lots. The resulting lot size distribution was highly skewed with a mean of 3789 m^2 (0.38 ha), a median of 3500 m^2 (0.35 ha), and a mode of 2500 m^2 (0.25 ha) (Fig. 4). A stratified sample of 150 of these lots was chosen to investigate the relationship between lot size and the ADI. A nonlinear curve-fitting procedure was used to find a satisfactory curve with which to represent that relationship (Fig. 5) (W.T.R.: 2). The findings indicated that the ADI of a cottage lot can be predicted from lot size. The response of many wildlife species to development was measured against the ADI, making it possible to calculate animal responses to development from information on lot size. This information is then available for all development.

Other findings included:

- Of the 1,036 cottage lots, 85% were less than 0.55 ha in size, and the lots ranged in size from 0.07 ha to 4.2 ha.
- Larger lots tended to be large at the expense of additional shoreline. The long axis of large lots tended to be parallel to the shoreline; that of smaller lots tended to be perpendicular.
- The mean number of buildings on the cottage lots was 2.2, and the mean distance of the main residential building from the water was 20.0 m ± 12.33.

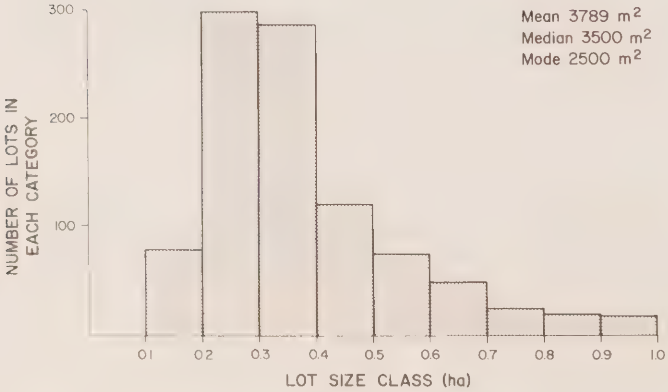


Figure 4. Cottage lot size distribution.

Regardless of the size of the lot, the area disturbed around the cottage remained the same, the mean area disturbed was 0.1333 ha. This implies that lots less than 0.1333 ha will have an ADI value of 3.0 and will be completely disturbed.

The ADI is valuable because it permits the prediction of potential disturbance to a vegetative community from a knowledge of lot size. Cottage developments with large lots, for example, are shown to have a proportionally smaller disturbing effect than those with smaller lots. Thus, the manipulation of lot sizes within a development proposal, using the ADI as a measure of acceptability, is a technique by which potential disturbance to wildlife can be minimized.

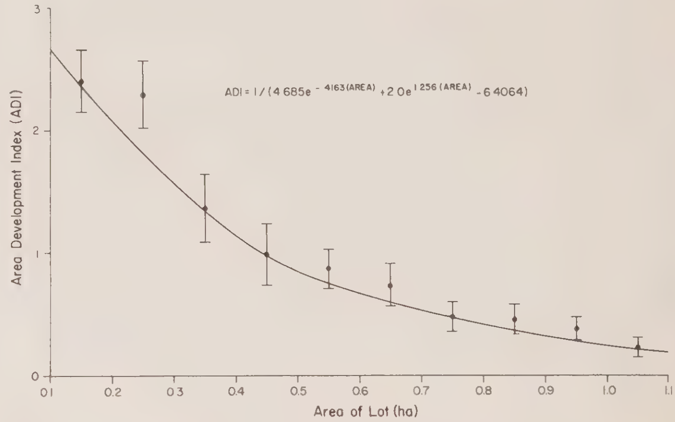


Figure 5. Relationship between the Area Development Index (ADI) and the area of the lot.

3.3 HABITAT AND VEGETATION

The first and probably most significant impact of cottage development on wildlife and wildlife habitat occurs through changes in vegetation. Any alteration to vegetation will affect the wildlife present. Therefore, measurement and analysis of that vegetation is an important starting point for this work.

Vegetation was sampled in the vicinity of physical signs of wildlife. For example, birds' nests, mink dens, and deer tracks in the snow provided evidence that these animals had found part of their life requirements in that particular area. These characteristics of habitat, also referred to as habitat variables, were quantified in order to predict the impacts of cottage development on these animals. The variables selected and the experimental design for each study (Table 2) were based on knowledge of the natural history of the species under examination. A more complete description of the field work is given in the technical papers listed in the appendix.

Due to differing species characteristics, it was not possible to study each species using the same technique. For example, the experimental design used to examine the characteristics of songbird habitat required a larger plot size than that of amphibians and reptiles. Many songbirds have elaborate behavioural patterns which require a certain habitat structure (James 1971), which was accounted for by larger plot sizes. Reptiles and amphibians, on the other hand, are much less mobile, and therefore the structure of their habitat is not as important for understanding their life requirements.

The above discussion briefly describes the rationale behind the Study approach. This information was then used to observe the way in which cottage development exerts an impact on wildlife.

Table 2. Summary of habitat sampling methods.

Animal Group	Objective	Number of Plots	Plot Size and Shape	Sub-Plot Size and Shape	Number of Variables*	Plot Determinant
Songbirds	Show Correlation with Area Development Index	73	20 x 50 m	$50 - 1\ m^2$	18	Conifer composition
Songbirds	Habitat description	73	100 x 100 m	11.3 m radius	22	Presence of singing males
Loons	To describe actual habitat	38	2 m radius	$5 - 1\ m^2$	45	Presence of nesting sites
Loons	To describe potential habitat	36	2 m radius	$5 - 1\ m^2$	45	Presence of nesting sites
Hawks	To describe macro habitat:					
	Broad-winged	25	100 m radius	10 x 10 m grid	17	Presence of nesting sites
	Red-shouldered	9	100 m radius	10 x 10 m grid	17	Presence of nesting sites
Hawks	To describe micro habitat:					
	Broad-winged	25	100 m radius	$10 - 1\ m^2$	20	Random (within 100 m circle)
	Red-shouldered	9	100 m radius	$10 - 1\ m^2$	20	Random (within 100 m circle)
Small Mammals	Quantitative habitat description	56	50 x 50 m	0 – 10 m $18 - 1\ m^2$	128	Systematic (within 50 x 50 m plot)
Mink	Description	94	50 x 10 m	None	30	Presence of den on shoreline
Amphibians and Reptiles	Habitat description:					
	Salamanders	82	1 m radius	None	23	Presence of egg masses
	Turtles	107	N/A	None	23	Presence of nesting sites
Amphibians and Reptiles	Habitat description:					
	Spring Peepers	145	N/A	N/A	23	Presence of calling males
Deer	Describe functional habitat:					
	Feeding	22	8 x 1.5 m	$4 - 1\ m^2$	18	Presence of field signs
	Day bedding	25	8 x 1.5 m	$4 - 1\ m^2$	18	Presence of field signs
	Night bedding	52	8 x 1.5 m	$4 - 1\ m^2$	18	Presence of field signs
	Travel lanes	28	8 x 1.5 m	$4 - 1\ m^2$		
Vegetation	Describe Area Development Index	73	2 – 20 x 50 m	$100 - 1\ m^2$	50	Conifer composition**

*Details in Wildlife Technical Report

**Various levels of conifer composition: <10%, 10 - 42.5% and > 42.5%.

3.4 EFFECTS OF COTTAGE DEVELOPMENT ON WILDLIFE AND HABITAT

3.4.1 FRAMEWORK FOR DISCUSSION

The framework used in the following discussion of each species or group of species was constructed to address four basic questions.

1) What procedures were used?
2) What were the significant results?
3) What do these results mean?
4) What are the applications to planning?

3.4.2 SONGBIRDS

Songbirds breeding in Muskoka-Haliburton depend on the availability of habitat. Some songbirds are dependent on very specific features of their habitat, while others can more easily adapt to a variety of characteristics. The red-eyed vireo (*Vireo olivaceus*), for example, specifically requires relatively mature trees. The American robin (*Turdus migratorius*), on the other hand, can exploit a wide range of conditions from those of lawns to less disturbed forest habitat. The disruption of the habitat-bird relationship through cottage development and the resulting effect on the songbird community was the subject of this work.

The Wildlife Component selected 73 study plots which were classified according to three levels of development: none, low, and high. These were further classified into two vegetation types: predominantly deciduous, and mixed wood where both coniferous and deciduous trees were present.

There were two basic procedures used to observe the effects of cottages on bird distribution. The first, the spot-map technique, isolated each songbird territory and, where possible, each nest. Study plots were monitored for four hours in the early morning when the songbirds were most active. Songbirds sing during their breeding season to mark their territory, therefore it is possible to locate the territorial boundaries by observing the birds and their interactions with neighboring birds. This technique was first described over 40 years ago (Williams 1936; Kendeigh 1944) (W.T.R.: 7), and has been used frequently ever since.

The second method singled out the singing posts and nest locations as points of reference to determine the variables of the vegetation that were important to the birds. For example, some warblers always breed where conifer trees are located. Therefore, this type of tree appears to be necessary for the successful reproductive activity of that species. This technique was introduced by James (1971). These singing post and nest locations were used to measure a number of vegetation variables in order to identify critical vegetation characteristics. It was then possible to measure how cottage construction changed those important characteristics.

In addition to determining the reaction of individual species to cottage development, measurement was made of the ways in which the songbird community changed with it. A unit refer-

red to as the Co-efficient of Community (CC), based on Jaccard (1932) was used:

$$CC = (c/ (a + b - c)) \times 100) \qquad (4)$$

where a = the number of species in the most highly developed plot.
b = the number of species in the plot being measured.
c = the number of species common to both plots.

Co-efficient of Community measured resemblance of any given plot's bird species composition to that of the most highly developed plot in the Study. Large values of CC indicated a species composition similar to that of a highly developed plot; small values of CC represented undeveloped plots. When CC is plotted against development, the relative changes in the songbird community can be shown because the slope of the line indicates relative changes in the songbird community (if no changes occur, the slope is 0.)

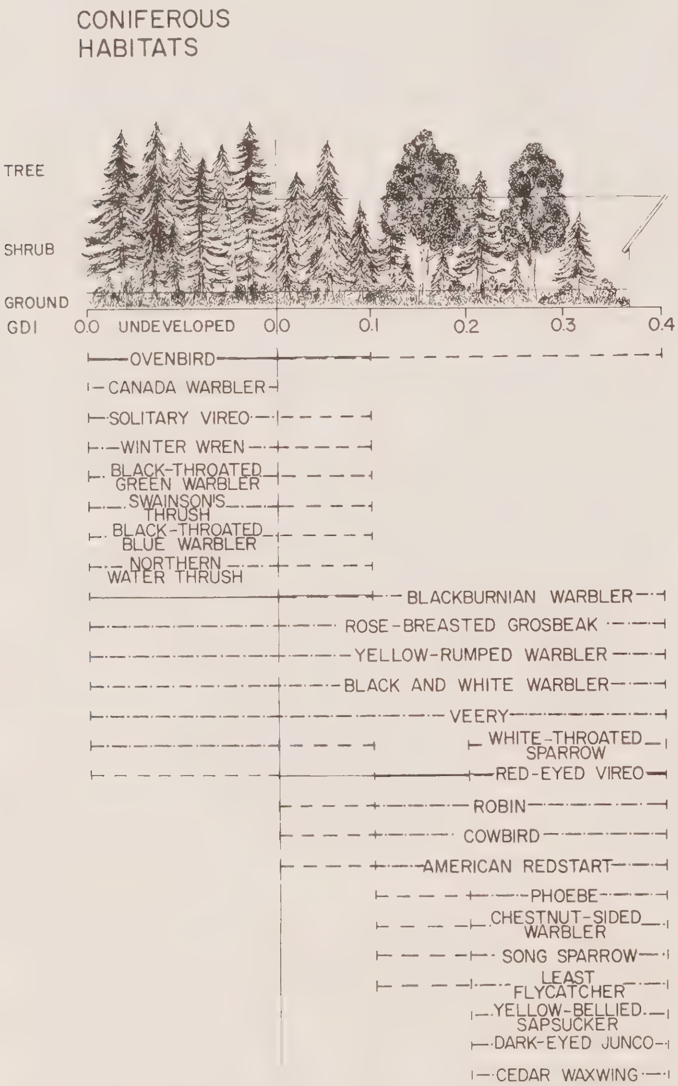


Figure 6. Songbirds in coniferous habitat at varying levels of development.

Some songbirds could not tolerate even low levels of development; while others seemed virtually unaffected. Some species benefitted from disturbance (Fig. 6, 7). Furthermore, as Figure 8 illustrates, the CC plotted against development (GDI) has a positive slope. This is a quantitative measurement of change in the songbird community as development intensifies. These results indicate that extensive cottage development changes the composition of the songbird community.

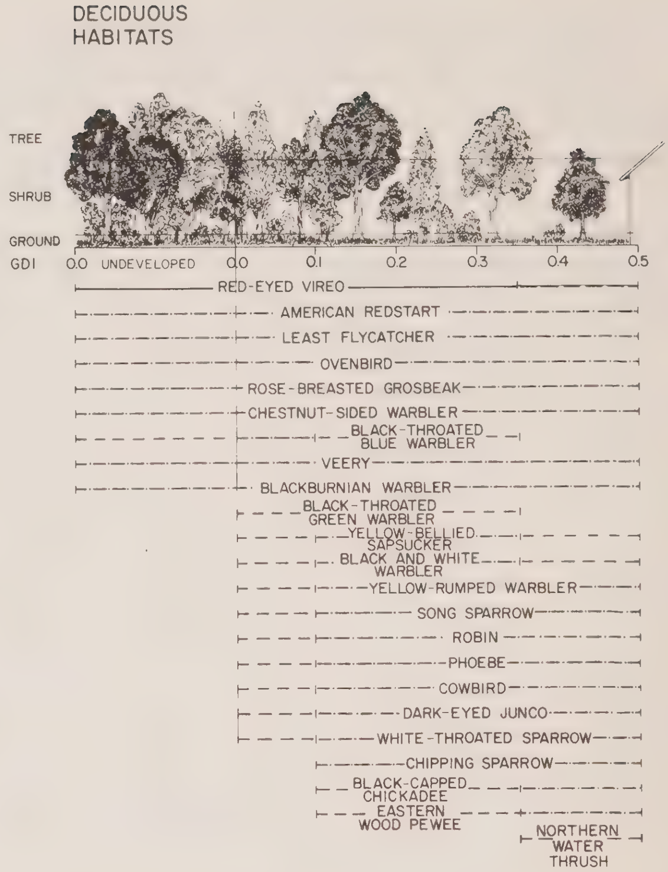


Figure 7. Songbirds in deciduous habitat at varying levels of development.

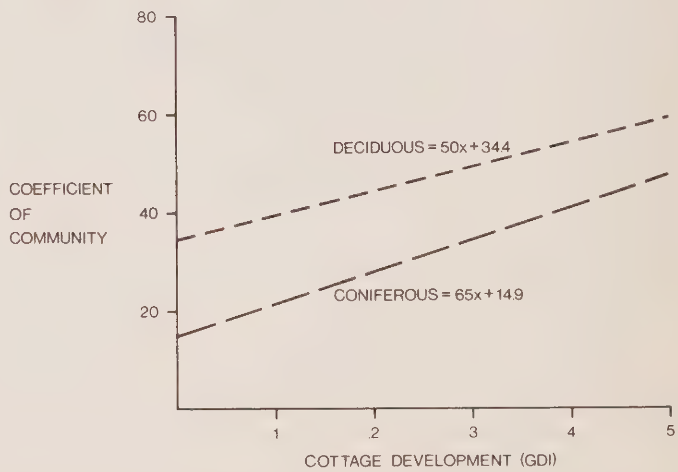


Figure 8. Co-efficient of Community (CC) vs. the Grouind Development Index (GDI).

If cottage development proposals are evaluated, using LAKELIFE, disturbance to songbird community structure can be kept to a minimum and no species need be eliminated from any lake shoreline. LAKELIFE accomplishes this by ensuring that the Co-efficient of Community remains the same on 25 percent of the lakeshore.

Fairly large, unbroken blocks of backshore habitat should be connected to shoreline preserves to ensure adequate interbreeding within a species to maintain its genetic diversity (MacClintock et al. 1977) (W.T.R.: 7). This also provides for species with territories larger than those studied.

3.4.3 COMMON LOONS

Increased human activity on lakes has been implicated in the reduction of common loon (*Gavia immer*) populations in the Boundary Waters Canoe Area in Minnesota (Titus 1979). In a one-year study conducted in Alberta, Vermeer (1973) found that a decrease in loons breeding on 19 lakes was related to an increase in human activity there. The purpose of this section of our study was to measure the impact of cottage activity on loons in the Study Area.

We examined the nesting success of loons on 40 lakes which represented a range of intensities of cottage development. One end of the continuum had no development while the other end had the maximum development that could be found. Over a four to six month period, these lakes were surveyed every two weeks to determine the number of eggs hatched and chicks raised to the fledgling stage. Human activity was monitored within 500 m of 16 selected nests (Table 3) and habitat characteristics were sampled around 38 actual nests and 36 potential nesting sites (W.T.R.: 4).

Table 3. Human disturbance around loon nests.

Element of Disturbance	Average Activity*	
	Nest in Developed Area**	Nest in Undeveloped Area
Large motorboats	14.9	0.0
Small motorboats	12.9	5.9
Non-motorized water craft	16.0	1.3
People on shore	28.4	0.0
Swimmers	0.8	0.0
Fishermen	8.6	0.0
Total	89.9	6.5

* Total number of occurrences of human activity of various types within 500 m of nest at 18 points in time (five minutes apart) averaged over four observations made during the nesting season (one in each four time periods: 0700-0830, 1000-1130, 1300-1430, 1600-1730).

**Nests in developed areas have at least three cottages within 150 m; undeveloped means no cottages within 250 m of nest.

Results indicated that small islands or bog hummocks (rounded knolls of vegetation or soil within a bog) were, by far, the preferred nesting sites. At least 75 percent of the nests were located in these areas. Characteristic features included gently sloping shoreline and abundant ground and shrub cover. There was also a marked tendency for loons to utilize the same nesting site over a period of consecutive years.

We defined a successful loon nest as one with at least a single egg hatching. Analysis revealed that successful and unsuccessful nesting sites had statistically similar habitat characteristics. Therefore, it must be assumed that non-habitat factors influence nesting as well.

Human activity around nests was related to the number of cottages near nesting sites (Table 3). Because significantly fewer successful nests were found to exist where the nearest cottage was within 400 m (Table 4), or where there were more than two cottages within 250 m (Table 5), the level of human activity was thought to be a factor in reduced nesting success.

Table 4. Distance of cottages from loon nests.*

Distance (m)	No. of Successful Nests	No. of Unsuccessful Nests
0 - 200	27	29
201 - 400	8	14
401 - 600	8	5
> 600	9	1
Total	52	49

*$x^2 = 8.76$, $p \leq 0.05$, df = 3 (for combined 1977, 1978 and 1979 data).

Loons are still commonly observed in Muskoka-Haliburton. However, it is not known whether the population is increasing or decreasing. This species can live up to 20 years in the wild, therefore it is impossible to detect the effects of changing reproductive success in a three-year study. This problem is compounded by the possibility that some loons become habituated to human activity near their nests (Titus 1979). If there is a slow increase in human activity over a period of years, loons may become habituated to it, and alter their behaviour to accommodate it.

Table 5. Cottage density and loon nesting success.

No. of Cottages Within 150 m of the Nest*	No. of Successful Nests	No. of Unsuccessful Nests
0	32	17
1	9	3
2	5	5
3	2	5
4	1	5
Total	49	35

*$x^2 = 10.11$, $p \leq 0.05$, df = 4 (for combined 1977, 1978 and 1979 data using first nesting attempts only).

As this research and that of other scientists (Vermeer 1973; McIntyre 1977) indicates, loons seldom nest on the mainland. Therefore it is specifically islands and bog hummocks that should be protected. It is recommended that at least two islands less than 0.5 ha in size be left undeveloped. Where these are not available, two 500 m lengths of shoreline centred on potential loon nesting sites should be left undisturbed to a depth of 100 m distance inland. Best potential onshore sites include low wetland areas less than 50 m from shore, bog hummocks or gently sloping shoreline, with abundant ground and shrub cover in relatively shallow water protected from wave action (W.T.R.: 4). These loon nesting areas could be situated within the reserves required for other species, but must be a continuous block of land.

3.4.4 HAWKS

Hawks are avian predators that incorporate large areas into their hunting range, and include a number of species in their diet (Fig. 1). Approximately 10 species of raptors occur in the Study area, but only the two found in high densities were examined in detail: the broad-winged hawk *(Buteo platypterus)* and the red-shouldered hawk *(Buteo lineatus)*.

During the course of field work on other species, an effort was made to locate as many hawk nests as possible. This was not intended as a population estimate but as a source of information about the impact of cottage development on their reproductive activity. Thirty-four nests of broad-winged and red-shouldered hawks were monitored throughout spring and early summer. The habitat surrounding each nest was studied to identify important characteristics necessary for the maintenance of these species (W.T.R.: 6).

Our results suggest that cottage development initially improves, or at least maintains, broad-winged hawk habitat. This species needs younger deciduous stands; and the construction of cottages and associated development (i.e. lawns, roads, and hydro lines) often produce this kind of forest. Typical nesting trees were yellow birch and beech. However, the greatest source of disturbance to the broad-winged hawk appears to be human activity. This species establishes nests, and is most conspicuous (Fig. 9) during late May which coincides with the major influx of cottagers around the Victoria Day weekend. This sudden intense activity could cause nest disturbance or desertion, because defense of the nesting site is weakest at this time of territorial establishment (Fyfe and Olendoff 1976).

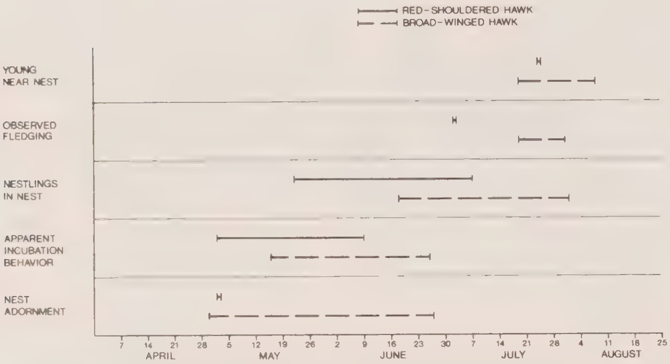


Figure 9. Broad-winged and red-shouldered hawk nesting chronology. H = Holiday.

This study documented nine nesting attempts of the red-shouldered hawk, a species considered to be declining in central Canada and elsewhere in its range (Brown 1971; Fyfe 1976). The examination of its habitat suggests that it responds negatively to cottage development. Since most observations of this raptor took place in uncottaged areas, the creation of clearings could be expected to reduce available habitat as open areas did not appear to be used for perching, hunting or territorial display. Red-shouldered hawk habitat falls into two broad categories; upland deciduous areas, and lowlands along streams and small rivers. The red-shouldered hawk requires a continuous forest size of at least 10 ha (Galli et al. 1976). Typical trees chosen for nesting were yellow birch and beech. Cottage roads circling lakes 50 to 100 m from shore could fracture and isolate valuable habitat along lakes and streams (Wiley 1975). On a large scale, destruction of red-shouldered hawk habitat has resulted in a reduction of breeding populations (Henny et al. 1973).

To ensure that hawk nesting habitat is available on a lake, two potential nesting sites should be reserved. These sites should be located along a stream valley. This valley could be small but is probably only identifiable from the lake surface (not from an aerial photograph). There must be 70 to 90% tree canopy cover, of which 20% should be close to mature (diameter at breast height greater than 40 cm), preferably containing yellow birch and beech and 10 to 30% coniferous (W.T.R.: 6). Nesting sites on a lakeshore should be surrounded by a 150 m x 150 m reserve. They could be located within reserves set aside for other species.

3.4.5 SMALL MAMMALS

Small mammals are important, if not always visible, components of shoreline wildlife communities. They play a role in nutrient cycling by converting plant and insect biomass into animal matter. Furthermore, they provide a food source for higher level predators such as mink and raptors birds (Fig. 1). Small mammals also possess some experiential value to those cottagers who enjoy viewing or feeding animals such as the red squirrel *(Tamiasciurus hudsonicus)* and chipmunk *(Tamias striatus)*.

On 56 plots established on the shorelines of 15 lakes, live traps were set for small mammals in July and August. Three trapping periods of three days each provided 324 trap nights (i.e. one trap set during the course of one night) per study plot. To indicate the abundance of small mammals on each, a Capture Index (CI) was defined as the number of captures recorded in 324 trap nights (W.T.R.: 9). Vegetation was sampled on nine subplots systematically distributed over each study plot.

The trapping conducted on the 56 sites yielded 2,013 animal captures in 18,144 trap nights for an 11.05% success rate (Table 6). The number of each species on the plot was found to change with the Area Development Index (Fig. 10). The response of small mammals to the level of development varied with the species and the coniferous composition of the habitat (Fig. 11). Intolerant species like the woodland jumping mouse *(Napeozapus insignis)*, the redback vole *(Clethrionomys gapperi)*, and the masked shrew *(Sorex cinereus)* not only declined in number as development increased, but were extirpated at high levels of development. Tolerant species like the red squirrel, deer mouse *(Peromyscus maniculatus)*, eastern chipmunk, and shorttail shrew *(Blarina brevicauda)*, changed in number but existed even at high development. The density of conifers in the habitat also influenced the response of small mammals to development (Fig. 11).

Table 6. Capture data for small mammal species.

Common Name	Scientific Name	No. of Captures	Capture Index*	Success Rate (%)
masked shrew	*Sorex cinereus*	30	0.535	0.02
smokey shrew	*Sorex fumeus*	6	0.107	0.03
short-tailed shrew	*Blarina brevicauda*	112	2.000	0.61
meadow vole	*Microtus pennsylvanicus*	10	0.178	0.05
woodland jumping mouse	*Napeozapus insignis*	48	0.857	0.26
deer mouse	*Peromyscus maniculatus*	843	15.053	4.64
eastern chipmunk	*Tamias striatus*	590	10.535	3.25
red squirrel	*Tamiasciurus hudsonicus*	54	0.964	0.29
Total		2013		11.05

*Capture Index is the number of captures of a species in 324 trap nights.

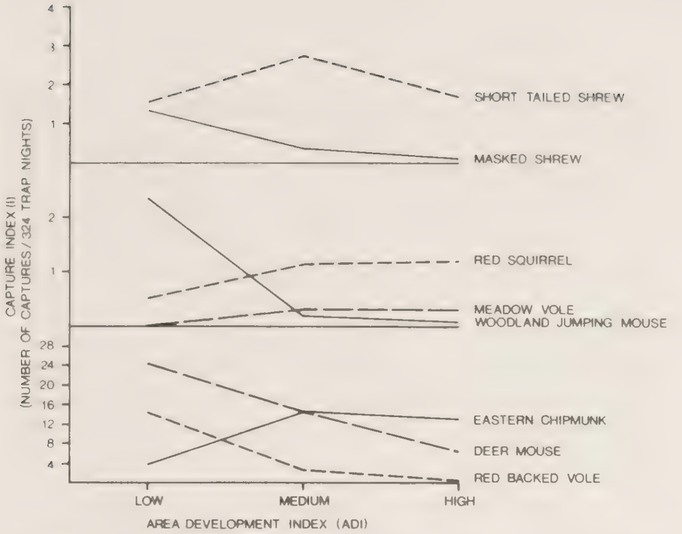


Figure 10. Relative abundance of small mammal species at various levels of the Area Development Index (ADI).

Since small mammals are virtually cosmopolitan, almost any area may be described by its small mammal community. Changes in the distribution and abundance of small mammals may indicate ecological perturbations affecting nutrient cycling, trophic structure, resource partitioning, and environmental quality (Golley et al. 1975). Species intolerant of development are directly affected by some of these changes in their habitat. Frequently, an animal is intolerant of development due to the extreme sensitivity of key habitat features on which it depends. For example, any disturbance of the tree, shrub, or ground layer will vastly alter the plant species composition of the ground vegetation on which the woodland jumping mouse depends. Therefore, on mixed shorelines, the woodland jumping mouse is extirpated at very low levels of cottage development. Other organisms dependent upon those vegetation types will also be affected.

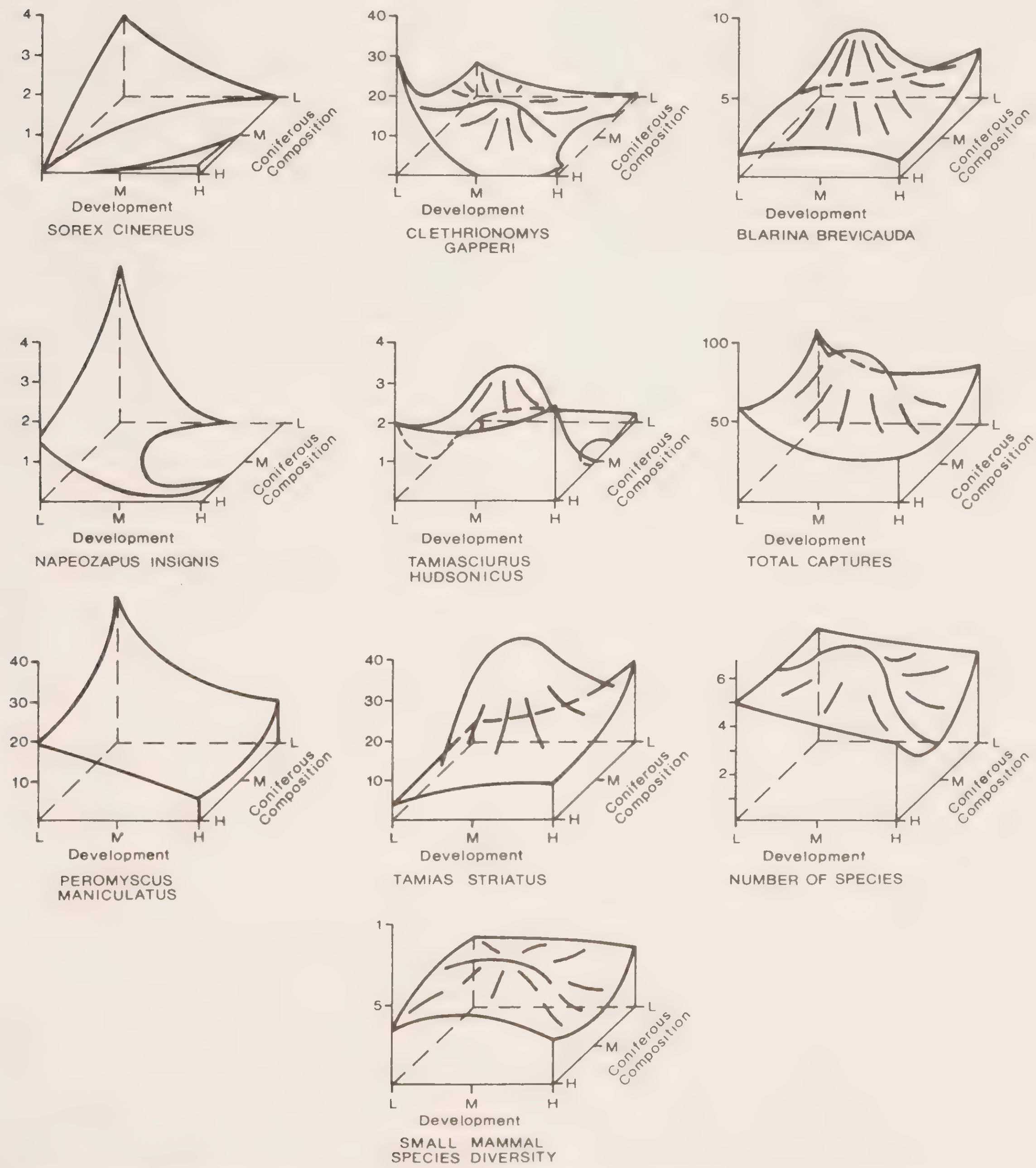


Figure 11. Three-dimensional representation of small mammal response to development and coniferous composition (L = Low, M = Medium, H = High).

To protect the small mammal community, an area of land on the lakeshore must be protected from development. This must: 1) represent the habitats of all the small mammal species studied; 2) be large enough that the small mammal populations are capable of maintaining their status in the pre-development food web; 3) be large enough to sustain a small mammal community with enough stability to survive mild, natural perturbation in biotic and abiotic factors. These criteria are met if 25 percent of the original habitat for each species is preserved after development. The LAKELIFE model predicts the amount of habitat for each species before and after a proposed development takes place.

3.4.6 MINK

Mink are carnivorous animals that live along lakeshores and streams throughout most of Ontario. They require a relatively undisturbed habitat and adequate food supplies to successfully reproduce. Their diet consists of aquatic animals like crayfish and frogs as well as terrestrial animals like mice and shrews. They are sensitive to changes in water quality, vegetative composition along shorelines, and abundance of their food supply (Gerell 1967; 1968) and, are good indicators of environmental perturbations.

Shorelines on 26 lakes were searched for signs of mink activity such as dens or feces (W.T.R.: 8). The frequency of these observations was compared to the amount of development on a lake by means of the Cottager Loading Development Index (CLDI) (Section 3.1) which approximately corresponds to an increase in human disturbance related to cottaging. Shoreline habitat characteristics were sampled on 94 plots selected to represent a wide range of development and habitat types. Each plot was classified as coniferous, deciduous, or mixed wood. In addition to studying mink habitat, some insight into mink feeding behaviour was gained from the analysis of feces with regard to prey species and their frequency of occurrence (W.T.R.: 8).

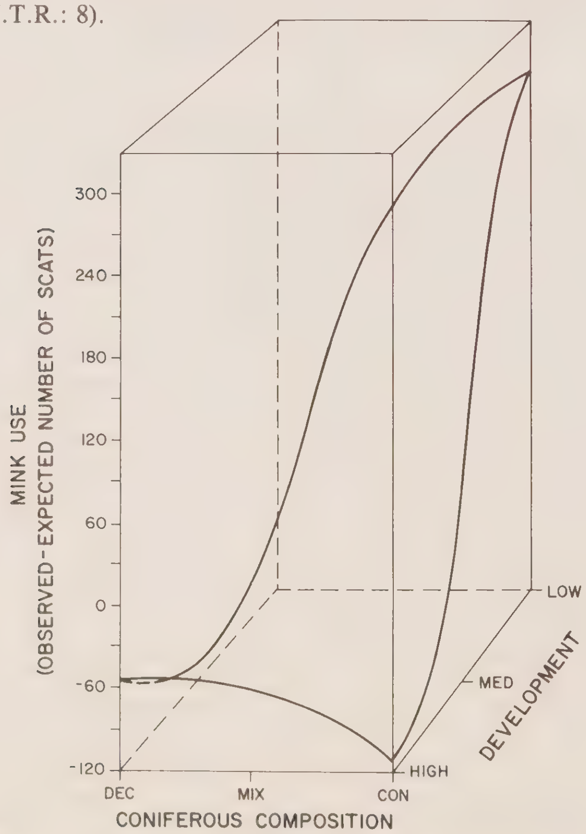


Figure 12. Mink response to development and habitat types.

Mink activity was greatest on undeveloped shorelines with coniferous and mixed vegetation types (W.T.R.: 8; Fig. 12). Deciduous shorelines were used very little, regardless of the level of development. The activity of mink decreased with even slight increases in the CLDI (Fig. 13). The decrease in mink activity was probably due to the reduction in available food, hunting locations, and denning sites. An analysis of mink food habits showed that their diet changed with habitat type and with the level of development on the lake (Fig. 14). The modified diet and the reduced number of mink on developed shorelines is caused by the impact of development on aquatic and terrestrial food webs.

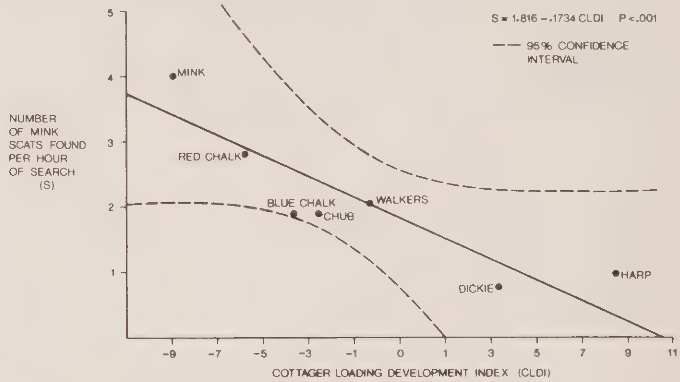


Figure 13. Relative mink activity vs. Cottager Loading Development Index (CLDI).

Observations made on the study lakes indicated that values of the CLDI greater than 1.0 restrict the quantity of mink habitat (Fig. 13). Planners should ensure that this Index has a value of less than 1.0 to preserve mink habitat along lakeshores. Although it is difficult to conceptualize the CLDI, it is easily implemented, using the LAKELIFE computer model.

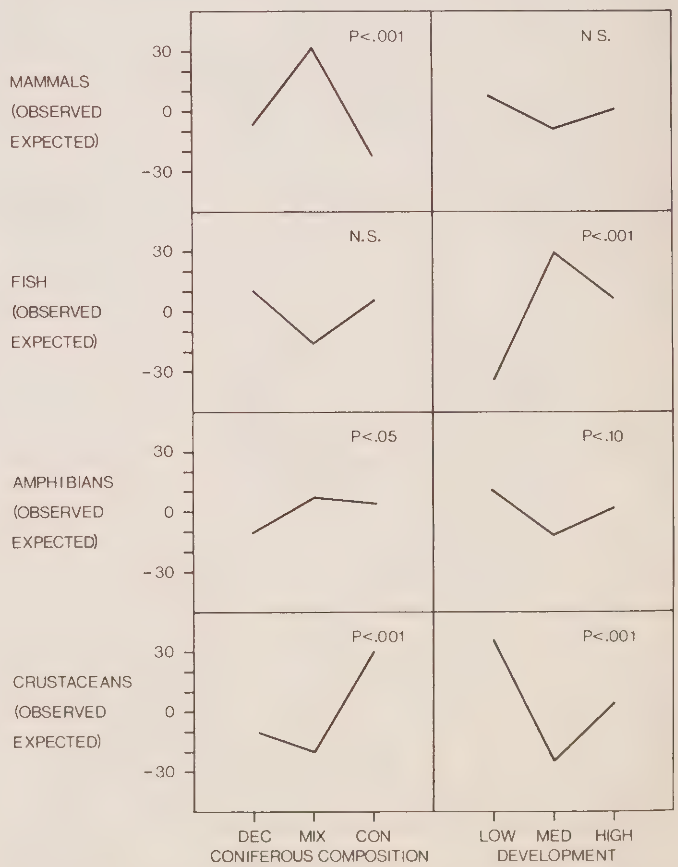


Figure 14. Variations in the occurrence of food items in mink scats with respect to habitat type and levels of development.

3.4.7 WHITE-TAILED DEER

White-tailed deer populations in central Ontario have recently experienced drastic declines in number (King 1976; Ontario 1978). This same region is also experiencing an increasing demand for lakeshore cottage development.

The major impact of cottage development on deer is habitat destruction, particularly in their winter concentration areas. In much of Muskoka-Haliburton, vegetation around lakes often has a major coniferous component that is used by these animals. This Study concentrated on the impact of cottage development on vegetation and the subsequent effect of this on the quality of deer habitat.

Table 7. Functional winter habitat characteristics of white-tailed deer.

Functional Habitat Types	No. of Samples	Field Signs*	Characteristics
Travel lanes	28	Tracks and trails	Dense continuous closed canopy
Night beds	52	Circular basin shaped depression in snow	Dense continuous closed canopy
Day beds	25	Circular basin shaped depression in snow	Little cover, good insolation
Feeding sites	22	Twig ends removed between 1 m and 3 m in height	Numerous shrubs

*Details outlined in W.T.R.: 10

The deer work was done in the winter when signs of activity could be seen in the snow. Four types of habitat were used by deer: (1) travel lanes (passageways usually from one conifer stand to another); (2) night bedding sites (protection against severe cold and wind); (3) day bedding sites (areas of insolation); and, (4) feeding sites (W.T.R.: 10). A number of vegetation measurements were taken to describe these habitat types (Table 7). Areas with and without cottages were compared to show the effect of human disturbance. These four habitat types exhibited significantly different characteristics. Night bedding areas and travel lanes had a dense, continuous, closed canopy of coniferous trees; day bedding sites had low overhead cover. As expected, the feeding areas contained the largest amount of food (Fig. 15).

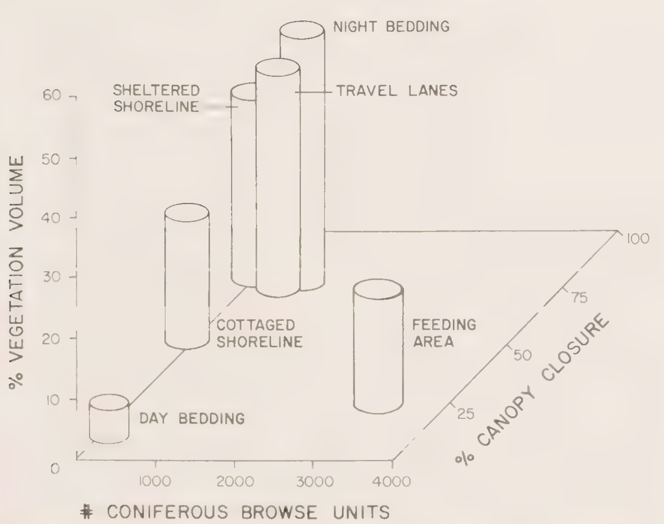


Figure 15. The relationship of functional habitat types, sheltered shoreline areas and cottaged coniferous areas to three habitat variables.

On shorelines with cottages, there was reduced shrub cover and a smaller percentage of coniferous tree and branch distribution, all of which had resulted from tree removal and pruning by cottagers. In some areas, some coniferous trees had been replaced by deciduous ones like white birch. Tree removal results in the division of continuous coniferous shoreline into smaller portions, thereby reducing its value to deer as night bedding areas and travel lanes in winter.

When cottages are built in these winter concentration areas of deer, the quality of deer habitat, upon which the welfare of the deer population depends, is reduced. Although careful planning of developments may alleviate this problem, the best way to preserve deer winter concentration areas is to prevent development.

The Ministry of Natural Resources maintains records of traditionally important deer concentration areas, including those not presently in use. These records can be used to designate areas which should not be disturbed. A field examination by Ministry of Natural Resources Fish and Wildlife staff may be necessary when no information is available about deer concentration areas in the vicinity of proposed developments.

3.4.8 REPTILES AND AMPHIBIANS

Reptiles and amphibians form an integral part of food chains as predators of insects and their larvae and as prey themselves to higher level consumers. Changes in their habitat often reflect alterations in water quality as well as vegetation.

As in the study of other species, the essential habitat requirements were examined. The characteristics of these were measured as were the levels of disturbance, using the Ground Development Index (GDI). Most species of amphibians require terrestrial and aquatic habitat features. Therefore, it was necessary to examine the vegetation and water chemistry of their habitats. Densities of amphibians were measured throughout spring and summer along streams, lakes, and ponds.

Seven species of amphibian were studied in 1979 and 1980. The observations of each are presented separately and in greater detail than in discussions of other wildlife, because very little information was previously available about the impact of human disturbance on these animals. Amphibians are most common in the moist habitats along streams and lakes which is where these species were studied.

The red-backed salamander *(Plethodon cinereus)* was found in undisturbed woodlands (W.T.R.: 11). This species is terrestrial, and therefore, unaffected by water chemistry. No habitat characteristics could be significantly correlated with its distribution which indicates flexibility of habitat usage by this species. The spotted salamander *(Ambystoma maculatum)* breeds in alkaline water conditions like those found in ditches created by road construction. This species was also associated with a range of habitat variables.

Suitable habitat for the spring peeper *(Hyla crucifer)* is a marsh with few shrubs and extensive ground cover that includes species like leatherleaf *(Chamaedaphne calyculata)* and sweet gale *(Myrica gale)*. This habitat is ideal for breeding males that require perching and calling sites with limited tree cover that does not impede sound transmission. On developed lakes, most breeding sites were found on emergent vegetation

especially at the inflows and outflows. When this is removed by cottagers, breeding habitat is destroyed.

The bullfrog *(Rana catesbeiana)* was associated with similar vegetation types as the spring peeper, but was more common in eutrophic waters. Submergent aquatic vegetation is abundant in its breeding habitat as is shoreline vegetation like bracken fern *(Pteridium aquilinum)* which usually occurs in open areas.

The green frog *(Rana clamitans)* was most common in undisturbed habitats where volume of ground vegetation was high and shrub and tree volume low. This species' distribution was not significantly related to water chemistry.

The wood frog *(Rana sylvatica)* was common along streams in undisturbed mature forests with extensive areas of royal fern *(Osmunda regalis)* and sensitive fern *(Onoclea sensibilis)* (W.T.R.: 12).

American toad *(Bufo americanus)* distribution was not associated with any water chemistry variables, reflecting their independence of aquatic habitats throughout most of the year. Toads were most common in undisturbed woodlands with extensive moss cover.

For all amphibians studied, except bullfrogs and spotted salamanders, disturbance caused by cottage development was detrimental to habitat quality. The integrity of the streams and lake littoral zones must be maintained by reserving a 50 m buffer zone on either side of the stream, running from the mouth along 100 m of the stream's course. This will preserve the aquatic and terrestrial components of most amphibian species' habitats.

The most common species of turtle in Muskoka-Haliburton are the snapping *(Chelydra serpentina)* and the eastern painted *(Chrysemys picta)* turtles. There were 166 turtle nesting sites observed, 56 of which were on developed lakes. Turtles require sandy areas within 200 m of water that are free of covering vegetation, and have a clear path to the water (W.T.R.: 11) in order to achieve optimum breeding success. The study of snapping turtles was intended to obtain a succinct habitat description for this species. Lonck and Obbard (1977) have indicated that nesting habitat may be the most critical. A study by Hammer (1969) stressed that this species can lose up to 75% of its nests to predation even in the absence of human activity. An examination of long-term impact fell beyond the scope of this five-year Study because turtles live up to 20 years. Nonetheless, it is clear that increasing road traffic and destruction of egg-laying sites have a negative effect on these animals. Therefore, it is recommended that a minimum of two suitable turtle nesting sites be left undeveloped on each lake. A 100 m area around each should be left undisturbed. In order to preserve the broadest habitat base while reserving the least amount of land, approximately 50% of stream inlets and outlets should be left undeveloped. Often the littoral zone is shallow in these areas, and aquatic plants fourish. These areas provide poor recreational facilities for people, but offer significant habitat for wildlife.

3.4.9 VEGETATION

The coniferous fringe, an obvious characteristic of most lakes in Muskoka-Haliburton, was examined extensively at 450 sites, on undisturbed shorelines. Each of the three vegetation types, deciduous, mixed, and coniferous, contained 150 sites. Each site was made up of three plots arranged at variable distances along a line perpendicular to the shore (W.T.R.: 1). To demonstrate changes in vegetation which occur as distance from shoreline increases, 29 vegetation variables were examined.

Analysis of this data showed that 29 variables in the three vegetation types were correlated with distance from shore (Table 8). Sixteen significant correlations were in the coniferous vegetation type (Table 8). Fewer significant correlations were found in the deciduous and mixed habitat types, indicating that they more closely resembled backshore areas.

Table 8. Vegetation variables correlated with distance from shore.

Vegetation Variable	Significance Levels		
	Deciduous (n = 150)	Mixed (n = 150)	Coniferous (n = 150)
Negative Correlates			
No. of conifer trees	0.05	0.01	0.01
% conifer composition (trees)	0.05	0.01	0.01
% conifer composition (shrubs)*	0.05	0.01	0.01
% conifer composition (shrubs)**		0.01	0.01
No. of conifer shrubs*		0.1	0.01
No. of conifer shrubs**			0.01
Stumps		0.01	0.01
Canopy Closure			0.01
% Bare Ground			0.01
Positive Correlates			
No. of deciduous trees			0.05
No. of deciduous shrubs*		0.01	0.05
No. of deciduous shrubs**		0.01	0.05
No. of shrub individuals*		0.01	
Canopy height	0.1		0.01
% Ground cover			0.05
Foliage height diversity #			0.01
% Litter cover			0.01

*Shrubs greater than 1 m in height and less than 8 cm dbh.
**Shrubs 1.5 m $<$height $<$9 m.
#MacArther and MacArther, 1961.

Data were also collected to provide detailed information about the changes which occurred with development. There were 55 quadrats of 1.0 ha studied in areas with various levels of development. To determine which type of vegetation was most disturbed, the data were analysed using correlations between vegetation variables and the Ground Development Index.

Negative correlations were found between the GDI and general vegetation variables such as number of tree individuals, tree and shrub cover, and volume (Table 9), indicating a significant deterioration in the structure and extent of the lakeshore vegetation community, both natural and introduced. This, combined with the negative association between native vegetation species and development, shows that there are two major impacts of development. First, natural lakeshore species are replaced by either domesticated or weed species which typically are associated with human disturbance, and second, there is an overall loss of vegetation. On the whole, community structure is affected considerably by development.

Table 9. Vegetation variables correlated with the Ground Development Index (G.D.I.).

Vegetation Variables		
Tree	Shrub	Ground
Negative Correlates		
No. of tree individuals	No. of shrub individuals	Ground volume
No. of conifer trees	No. of conifer shrubs	No. of wood fern
No. of deciduous trees	No. of deciduous shrubs	Frequency wood fern
No. of hemlock	No. of shrub snags	No. of goldthread
No. of yellow birch	No. of balsam fir shrubs	Frequency goldthread
Tree cover	No. of black cherry	
Tree volume	No. of beaked hazel	
Percent conifer cover	Shrub cover	
Percent conifer volume		
No. of snags*		
Positive Correlates		
		No. of dandelion
		Frequency dandelion
		No. of Hawkweed
		No. of raspberry
		Frequency raspberry

*Both tree and shrub snags are included in this variable ($p < 0.05$).

Unaltered vegetative communities should be maintained not only for their own sake but for those cottagers who value the natural environment of Ontario. The results of this Study suggest that 20% of deciduous and 30% of coniferous areas be left undisturbed. This would usually result in the exclusion of 25% of a shoreline from development where half of the lake is coniferous and half deciduous. This block of land would provide habitat for several animal species as well, and could include the reserves set aside for other species. The integrity of the reserved land would be enhanced by large, continuous areas of land rather than numerous, small parcels.

4. RECOMMENDATIONS

4.1 INTRODUCTION

The research of the wildlife component was aimed at identifying and measuring the impacts of cottage development on wildlife populations and their habitat. There is another necessary step beyond identification and measurement of impacts; that step is evaluation. Although this is necessary in any environmental impact assessment process, as Knetch and Freeman (1979) point out, the evaluation process is not accomplished to any degree in the majority of assessments.

In the evaluation of impacts, the goal is to assist planners and decision-makers to judge the acceptability of the impacts or changes resulting from cottage development. Most, if not all, human activities cause change in natural systems. Change in the wildlife community is an inevitable result of cottage development of any kind or intensity. Still, the degree of change which is acceptable must be determined. Judgements of the acceptability of environmental change are necessarily subjective – based on values, attitudes, and beliefs (Matthews 1975). If these judgements are to be of help to decision-makers, the premises on which they are based must be clear.

4.2 PREMISES

The following premises were used to evaluate the acceptability of cottage development impacts.

1) Wildlife populations must be maintained in self-sustaining communities, that are as similar as possible to undisturbed shoreline communities, on some portions of all lakes but not everywhere on all lakes. The emphasis is on the community as a whole rather than an individual species or group of species.
2) There must be no extirpation of any species from the shoreline community of any lake.

4.3 EVALUATION

The recommendations of this Study are designed to benefit the wildlife community as a whole, not only to protect individual species or groups. It is the responsibility of the planner or other decision-maker to allocate land that can fulfill as many recommendations as possible. Along a stream, for example, the habitat left undisturbed could protect amphibians and other small aquatic life as well as broad-winged hawk nesting sites, small mammal and songbird habitat, and other wildlife species in the community.

On the other hand, if the minimum requirements of these recommendations are not met, there exists the potential for serious losses to individual lake shoreline communities. Clearings made for cottage development alter habitat structure sufficiently that the small mammal and songbird species which require a closed canopy, small openings, and/or mature forest would disappear from the shoreline. The combined effect of the reduction in diversity and abundance of songbirds, small mammals, and amphibians would change the natural food web, and thereby reduce the number of predators such as mink. Even though these predators could resort to prey species like chipmunks and robins that increase in number with development, they would still be negatively affected by disruption of their denning and breeding sites. The loss of hawks or loons from a lake shoreline due to disturbance of the nesting location may not be apparent in the short term because these birds have a long lifespan. However, these species could eventually disappear from developed lakes.

As these examples illustrate, it can become difficult to assess the cumulative impacts on wildlife populations over a long period of time. It is equally difficult to evaluate the impact over a large area as LAKELIFE is geared specifically for use on a single lake or logical section of a larger body of water. Nonetheless, the cumulative impact of development over a larger area, incorporating more than one lake and associated backshore and between-lake areas must be considered.

It is possible that development on somes lakes may already be unacceptable, according to LAKELIFE and these recommendations. This cannot be remedied. The planner's large scale evaluation may require the rezoning of these areas, prohibiting development from some lakeshores entirely, while letting development take precedence over wildlife on others.

Although the mandate of the Wildlife Component was to study the impacts of cottage development on wildlife, there are other human impacts on the lakeshore communities, including acid precipitation, introduction of heavy metals, the use of pesticides, resource extraction, hunting, and fishing that must be noted. Any conclusion, recommendation or guideline of the Lakeshore Capacity Study should be considered in light of the possible existence of additional negative impacts or synergistic effects of other stresses.

4.4 RECOMMENDATIONS

1) A Lakeshore Habitat Monitoring System should be introduced in areas where lakeshore cottage development occurs. This System should:
   (a) identify all potentially significant impacts of cottage development on lakeshore wildlife and wildlife habitat for each lake;
   (b) build an inventory of lakeshore habitats; and,
   (c) act as a data base with which cottage development plans can be evaluated, using LAKELIFE to try out different management strategies.

   The first stage of this System should involve the collection of data required to execute the program for the LAKELIFE Simulation Model and the identification of sensitive areas on the lake shoreline.

2) Development of any kind should not be permitted if filling of wetlands is required, or if wetlands areas are to be isolated from the lake. (A wetland is any area covered by standing water until about July 1st each year.)

3) All shoreline habitats for rare, threatened, or endangered species, both plant and animal, should be treated in accordance with current legislation and protected.

4) In order to preserve at least one pair of nesting loons on each lake, two islands of at least 0.5 ha or less should be left undeveloped. On lakes without two islands of that size, two areas centered on a potential loon nest site of at least 500 m of shoreline and 100 m inland should be reserved.

5) Any lakeshore identified as a winter deer concentration area should be protected, but the area reserved need not exceed 5% of the total shoreline length. Service lines and roads passing through these areas to cottages elsewhere on the lake should be no closer than 120 m from the shoreline.

6) At least two potential turtle egg-laying sites should be left undeveloped on each lake. Each site should be at least 1 ha in area with at least 100 m of shore.

7) To maintain amphibian populations, no cottage development should be allowed in 50% of the segments (as defined in LAKELIFE) containing a stream entering or leaving a lake.

8) To maintain hawk nesting sites along lakeshores, at least two actual or suitable nesting areas should be designated. No cottage development should be permitted within 150 m.

9) In order to adequately evaluate the impact of cottage development on all of the species mentioned above, as well as songbirds, small mammals, and mink, LAKELIFE should be used. LAKELIFE predicts the impact on wildlife habitat of proposed cottage developments, and reduces the complex requirements of all these species to a series of simple values which can be easily interpreted (see PART II, this report). The following are the minimum levels of values computed by LAKELIFE which will allow the objectives of this study to be met:

   - The small mammal Capture Index must not decline below 25% of its original value for each of the seven indicator species.
   - Mink activity should not be allowed to decrease below one-third of its value before development. The Cottager Loading Development Index also reflects good mink habitat, and must be below 1.0.
   - For each of the 19 songbird species listed in LAKELIFE, 25% of the original nesting habitat must be preserved. In addition, the Co-efficient of Community, a measure of the change in bird species, must remain the same on 25% of the lakeshore.

   In addition to these, loon, hawk, turtle, and amphibian habitat requirements are incorporated into LAKELIFE, based on the recommendations listed above.

Table 10. Lakeshore habitat to be left undisturbed in order to protect wildlife.

	Relative Value of Habitat*	Percent of shoreline which should be undisturbed	Minimum number of 100 x 100 m segments which should be left undisturbed
Deciduous Habitat (<20 percent conifer)	1.0	20%	6
Coniferous and Mixed Habitat (>20 percent conifer)	1.5	30%	7

*a subjective ranking based on interpretation found in the Wildlife Technical Reports.

10) If, due to lack of time or some other reason, the planner finds it impossible to use LAKELIFE, then the following guideline will give rough approximations. Every lake should have at least one area that is completely undisturbed in order to preserve natural biological communities. It may overlap other reserved areas and should be left as a continuous block where applicable (Table 10). A corridor of undisturbed land to a larger forest tract of at least 1,000 ha should be retained.

5. LITERATURE CITED

Brown, W.H. 1971. *Winter population trends in the red-shouldered hawk.* **Am. Birds** 25: 813-817.

Chapman, L.J. 1975. *Physiography of the Georgian Bay – Ottawa Valley area of southern Ontario.* Ont. Min. Nat. Res., Div. Mines, **Geoscience Rep.** 128. 50 pp.

Fyfe, R.W. 1976. *Status of Canadian raptor populations.* **Can. Field-Nat.** 90: 370-375.

Fyfe, R.W. and R.R. Olendoff. 1976. *Minimizing the dangers of nesting studies to raptors and other sensitive species.* Can. Wildl. Serv., Occas. Pap. 23. 17 pp.

Galli, A.E., C.F. Leck, and R.T. Forman. 1976. *Avian distribution patterns in forest islands of different sizes in central New Jersey.* **Auk** 93: 356-364.

Gerell, R. 1967. *Food selection in relation to habitat in mink (Mustela vison Schreber) in Sweden.* **Oikos** 18: 233-246.

Golley, F.B., K. Petrusewicz and L. Ryszkowski, Eds. 1975. **Small mammals: their productivity and population dynamics.** Cambridge University Press, Cambridge. 451 pp.

Hammer, D.A. 1969. *Parameters of a marsh snapping turtle population, LaCreek refuge, South Dakota.* **J. Wildl. Manage.** 33(4): 995-1005.

Henney, C.J., F.C. Schmid, E.M. Nartin, and L.L. Hood. 1973. *Territorial behaviour, pesticides, and the population ecology of red-shouldered hawks in central Maryland,* 1943-1971. **Ecology** 54: 545-554.

Jaccard, P. 1932. *Die statistisch-floristische Methoden als Grundlage der Pflanzen-sociologie.* **Handbuch der Biologischen Arbeitsmethoden** 5: 165-202.

James, F.C. 1971. *Ordinations of habitat relationships among breeding birds.* **Wilson Bull.** 83: 215-236.

Kendeigh, S.C. 1944. *Measurement of bird populations.* **Ecol. Monogr.** 14: 67-106.

King, D.R. 1976. *Estimates of the white-tailed deer population and mortality in central Ontario,* 1970-72. **Can. Field-Nat.** 90: 29-36.

Knetch, J. and P.H. Freeman. 1979. *Environmental and economic assessment in development planning.* **J. Environ. Manage.** 9: 237-246.

Loncke, D.J. and M.E. Obbard. 1977. *Tag success, dimensions, clutch size and nesting site fidelity for the snapping turtle, Chelydra serpentina, (Reptilia, Testudines, Chelydridae) in Algonquin Park, Ontario, Canada.* **J. Herpetol.** 11(2): 243-244.

MacClintock, L., R.F. Whitcomb, and B.L. Whitcomb. 1977. *Evidence for the value of corridors and minimization of isolation in preservation of biotic diversity.* **Am. Birds** 31: 6-16.

Matthews, W.H. 1975. *Objective and subjective judgements in environmental impact analysis.* **Environ. Conserv.** 2(2): 121-131.

McIntyre, J.W. 1977. *Artificial islands as nest sites for common loons.* **J. Wildl. Manage.** 41: 317-319.

Ontario, 1978. **Ontario deer management, Problems and Solutions.** Ont. Min. Nat. Res., Toronto, Ont., 260 pp.

Rowe, J.C. 1972. *Forest Regions of Canada.* **Can. For. Serv. Publ.** 1300. 172 pp.

Titus, J. 1979. *Response of the common loon (Gavia immer) to recreational pressure in the Boundary Waters Canoe Area, northeastern Minnesota.* Ph.D. Dissertation, State Univ., Syracuse, N.Y.

Vermeer, K. 1973. *Some aspects of the nesting requirements of common loons in Alberta.* **Wilson Bull.** 85: 429-435.

Whittaker, R.H. 1975. **Communities and Ecosystems.** Macmillan Publ. Co., N.Y. 385 pp.

Wiley, J.W. 1975. *The nesting and reproductive success of red-tailed hawks and red-shouldered hawks in Orange County, California, 1973.* **Condor** 77: 133-139.

Williams, A.B. 1936. *The composition and dynamics of a beech-maple climax community.* **Ecol. Monogr.** 6: 317-408.

6. APPENDIX

LIST OF RESEARCH PAPERS APPEARING IN THE WILDLIFE TECHNICAL REPORT (W.T.R.)

1. Clark, T., and D. Euler. 1981. Vegetation disturbance caused by cottage development in central Ontario.
2. Racey, G. and D. Euler. 1981. An index of habitat disturbance for lakeshore cottage development.
3. Clark, K., D. Euler and E. Armstrong. 1981. Habitat associations of breeding birds in cottaged and uncottaged areas of central Ontario.
4. Heimberger, M., D. Euler, and J. Barr. 1981. The impact of cottage development on common loon reproductive success in central Ontario.
5. Armstrong, E., D. Euler and K. Clark. 1981. Habitat selection within four passerine families in central Ontario.
6. Armstrong, E., and D. Euler. 1981. Reproductive ecology and habitat usage of woodland buteos in central Ontario.
7. Clark, K., D. Euler and E. Armstrong. 1981. Predicting avian community responses to lakeshore cottage development.
8. Racey, G. and D. Euler. 1981. Changes in mink habitat and food selection as influenced by cottage development in central Ontario.
9. Racey, G. and D. Euler. 1981. Small mammal and habitat response to shoreline cottage development in central Ontario.
10. Armstrong, E., G. Racey and D. Euler. 1981. Deer Habitat quality and influence of cottage development in central Ontario.
11. Clark, K., and D. Euler. 1981. Reptile and amphibian habitat and human activity in central Ontario.
12. Clark, K., and D. Euler. 1981. The importance of pH and habitat disturbance in amphibian distribution in central Ontario.

PART II

ASSESSMENT OF THE IMPACT OF COTTAGE DEVELOPMENT ON WILDLIFE AND FISH HABITAT USING A COMPUTER MODEL.

1. INTRODUCTION

LAKELIFE is a computerized information system to be used to evaluate the impact of shoreline cottage development on wildlife and wildlife habitat. LAKELIFE is a tool which planners and other professionals can utilize in the decision-making process. It involves the use of a computer in a simple question and answer fashion, so that large amounts of information may be processed quickly to provide an easily interpreted output. This procedure will facilitate the planning of cottage development, particularly in the Muskoka-Haliburton area. LAKELIFE may however be adapted for use in other parts of Ontario.

LAKELIFE does not require a fully trained computer operator to use it. In fact, all instructions needed to execute the model are contained in the following pages.

LAKELIFE incorporates the results of several years of research conducted by the Wildlife Component of the Lakeshore Capacity Study (LCS). It provides a generalized interpretation of the changes in wildlife habitat (including fish habitat in the littoral zone) resulting from existing and/or proposed cottage development. Once development is assessed, planners may modify development proposals in order to mitigate the disturbance to wildlife habitat.

The procedure requires the following steps (Fig. 1).

1) Preliminary information about development on the lake in question is acquired.
2) General habitat information from aerial photos, field trips to the lake, and other sources is assembled.
3) The above information is entered into the computer.
4) The computer predicts the resulting changes in the wildlife community so that an evaluation of their acceptability can be made.
5) The planner modifies the development proposals, and enters these modifications into the computer. When used in an iterative fashion, the process results in a proposal with an acceptable impact on wildlife communities.

LAKELIFE can be applied to lakes which are partially developed by taking values from existing and proposed development and predicting combined impact.

In many cases, the ecological implications of development to wildlife communities are more significant than is initially apparent upon examination of the effects on a single species. The animals considered by LAKELIFE were chosen, in part, because they indicate environmental conditions as a whole. The use of these indicator species greatly increases the value of LAKELIFE to the planner or biologist.

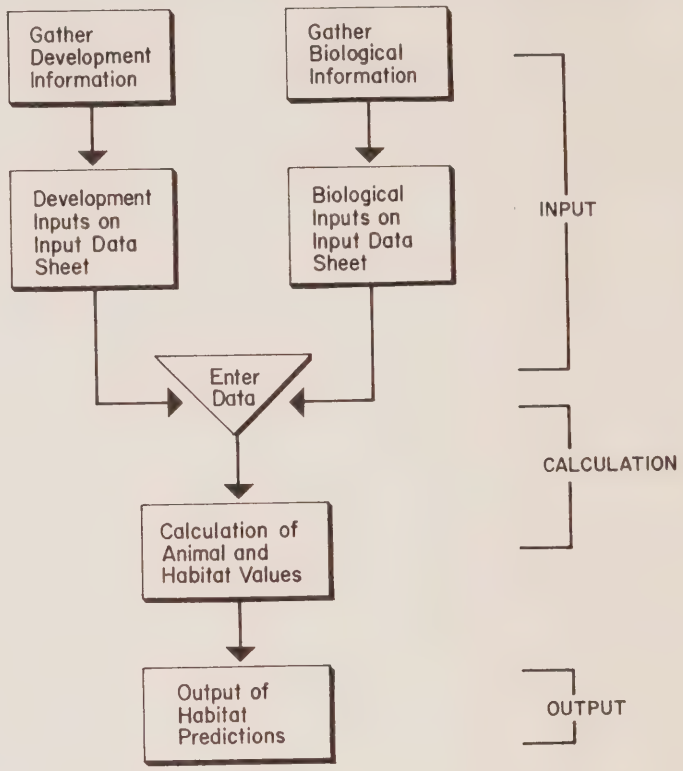


Figure 1. System flowchart: input, calculations, and output of the LAKELIFE modelling process.

The model is written in FORTRAN IV, a computer language which is useful in scientific and mathematical applications. LAKELIFE can be used anywhere in Ontario where access to the Queen's Park Computing Branch (Toronto) is available. It can be used in an interactive mode (TSO), by following the directions in this manual, or in a non-interactive mode (batch processing) (Appendix A). Any information about the system which is not contained in this manual can be obtained from the Ontario Ministry of Natural Resources (OMNR) by contacting the Director, Wildlife Branch, Toronto. This document is Part II of the report of the Wildlife Component of the LCS. The Wildlife Report Part I discusses the information and recommendations upon which LAKELIFE is based.

2. DETAILED DESCRIPTION OF INPUT

2.1 ASSEMBLING INFORMATION

The following information must be assembled prior to using the computer. This is a guide only, and the planner is encouraged to use any other information sources available (e.g. Lake Surveys and fishing maps).

It is recommended that planners contact and discuss the development proposals in person with the Wildlife staff at the appropriate Ministry of Natural Resources District or Regional Office. Frequently, other information not explicitly discussed in this manual may be available and beneficial to the modelling process.

LAKELIFE is geared to lakes with less than 10 km of shoreline. However, larger lakes can be evaluated by dividing into smaller units, each of which has less than 10 km of shoreline.

Aerial photographs are necessary for general surveillance of the lake and delineation of specific habitat types and topographical features. These features may be marked on acetate sheets positioned over a photograph or sketch of the lake. An aerial photo taken in a leaf-free, snow-free condition is preferable. A chronoflex enlargement of an aerial photo (scale 1:5000) is also useful, if available.

There are two types of input. The first is general habitat information, including shoreline vegetation composition, location of suitable loon *(Gavia immer)*, broad-winged hawk *(Buteo platypterus)*, and turtle nesting areas, location of winter concentration areas of deer, and streams used by breeding amphibians.

At least one visit to the site is necessary to determine certain input requirements (e.g. suitable hawk and loon nesting sites). This also gives the planner the opportunity to visualize the outcome of planning decisions.

The second type of input, development information, is obtained from detailed development proposals. If the lake has been partially developed, the plans for the existing cottage lots should also be acquired from local municipal offices, if available. The computer will require locations and sizes of both developed and proposed lots.

Once the two types of input have been obtained, they must be transposed onto the LAKELIFE INPUT DATA SHEET (Fig. 2) which provides a concise, functional format that allows ready transferral of this information to the computer. It is essential that this sheet be completely filled out prior to using the computer.

General habitat and development information is recorded in the spaces provided on the Input Data Sheet. The lakeshore must be divided into smaller units called segments. Information is recorded segment by segment on the lower part of the form.

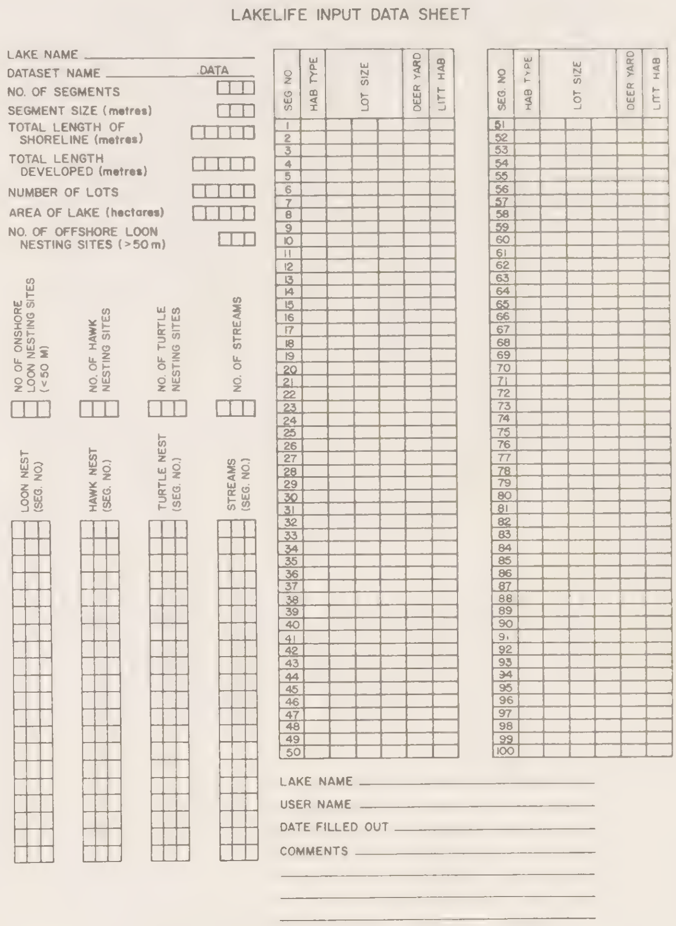


Figure 2. LAKELIFE Input Data Sheet.

Four inputs are required for each segment: habitat type (HAB TYPE), average lot size (LOT SIZE), deer yard capability (DEER YARD), and littoral zone (LITT HAB). All except lot size are expressed as single-digit numbers. Lot size is given in hectares (ha) to two decimal places.

2.2 COMPLETING THE LAKELIFE INPUT DATA SHEET

A. FILL IN THE LAKE NAME AND THE DATASET NAME ON THE INPUT DATA SHEET.

- Fill in the name of the lake.
- The dataset name has eight characters[1] or less which must be unique to that lake. It must be followed by ".DATA" as follows:

lakename.DATA[2]

1 Refer to naming conventions in TSO Users' Guide for the system being used, or contact support staff.

2 For additional information, see the full example in Figure 8.

B. DIVIDE THE SHORELINE INTO SEGMENTS, AND ENTER THE SEGMENT SIZE AND NUMBER ON THE INPUT DATA SHEET.

- Mark the public access point on the lake.
- Divide the shoreline into segments, number them in a clockwise direction, and enter the size and number on the Input Data Sheet. A segment is a uniform length of shoreline of 50, 100 or 200 metres. Use as small a segment size as convenience permits (segment sizes of 50 m or 100 m are best).
- If the lake has more than 10 km of shoreline, it will be necessary to divide it into sections, each of which may be evaluated separately using LAKELIFE. The lake should be divided into logical sections (i.e. large bays, etc.). Similarly, a planner may be interested in proposed development on one section of shoreline of a large lake. In this case, this section of shoreline should be treated as one lake.

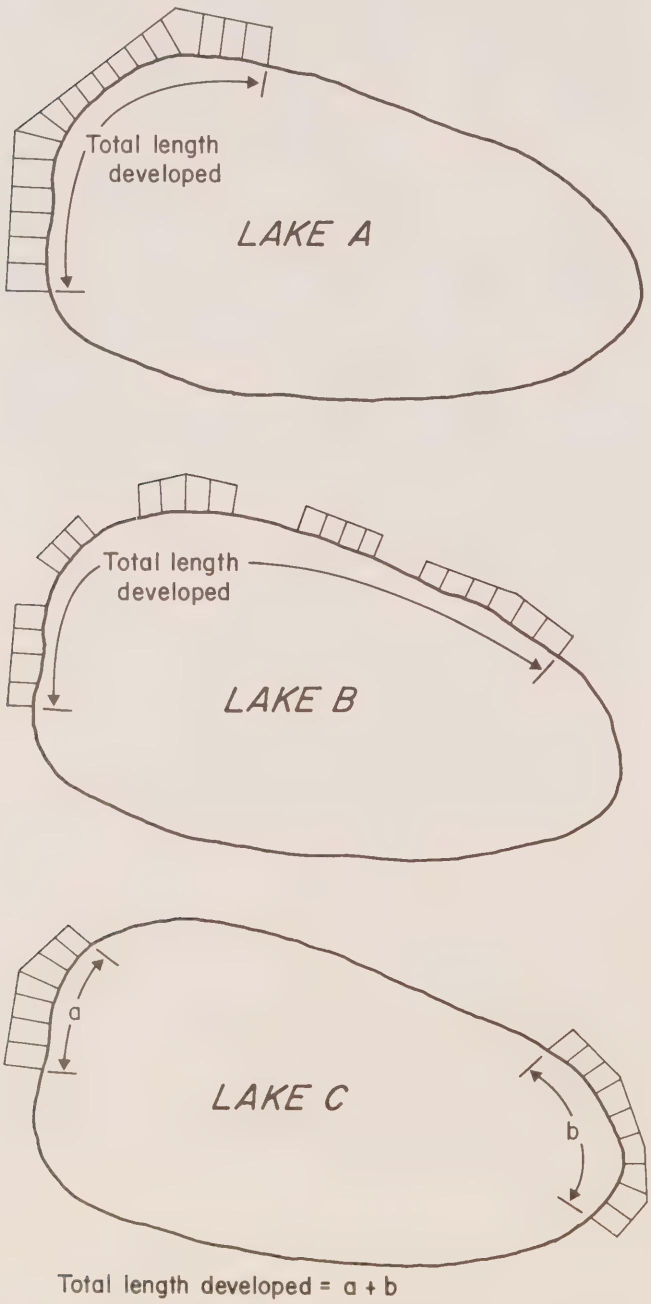


Figure 3. Calculation of the total length of developed shoreline.

C. ENTER THE TOTAL LENGTH OF SHORELINE, LENGTH OF DEVELOPED SHORELINE, AND THE NUMBER OF COTTAGE LOTS ON THE INPUT DATA SHEET.

- Total length of shoreline, in metres, will be equal to the number of segments multiplied by the segment size.
- Total length of developed shoreline includes existing and proposed development. It is calculated as the continuous length of shoreline that is fronted by development which has no gaps between lots in excess of 200 m (Fig. 3).
- The number of existing and proposed lots are counted and entered on the Input Data Sheet.

D. DETERMINE THE AREA (ha) OF THE LAKE AND FILL OUT ON THE INPUT DATA SHEET.

- This information is frequently found on Lake Surveys and fishing maps.

E. ASSIGN HABITAT TYPE AND ENTER ON THE INPUT DATA SHEET (HAB TYPE).

- Each segment of the shoreline must be assigned a habitat type determined from an aerial photo or a field survey.
- Habitat is classified as deciduous, mixed, or coniferous (Fig. 4; Table 1).
- Designate the habitat types for each segment: "1" for deciduous, "2" for mixed, and "3" for coniferous, and record on the Input Data Sheet.

Table 1. Habitat terms and code numbers for the identification of wildlife habitat types.

Type	Definition	Code No.
Deciduous	deciduous-dominated forest along the shoreline, with no coniferous fringe (Fig. 4a, b, c, d, e, f).	1
Mixed	deciduous backshore area with coniferous fringe greater than 5 m wide, but less than 20 m wide, or no domination by either coniferous or deciduous trees within 50 m of the shoreline (Fig. 4g, h, i, j, k, l).	2
Coniferous	coniferous-dominated forest over the area less than 50 m from the shoreline, or a deciduous or mixed backshore area with a coniferous fringe greater than 20 m deep (Fig. 4m, n, o, p, q, r).	3

F. ENTER THE AVERAGE LOT SIZE ON THE INPUT DATA SHEET

- This step is very important, because it ultimately affects the predictions of impact on wildlife habitat.
- Individual lot sizes are calculated by multiplying the frontage by 50 m. Average lot size, the value required on the Input Data Sheet, is the average of the individual lot sizes (in ha) in a segment.
- If there are no cottages in a segment, average lot size is 0.
- There are two possible approaches which the planner may take in this step of data preparation as follows:

APPROACH 1

If formal development plans are not yet approved and modifications can be made, this approach provides a quick ap-

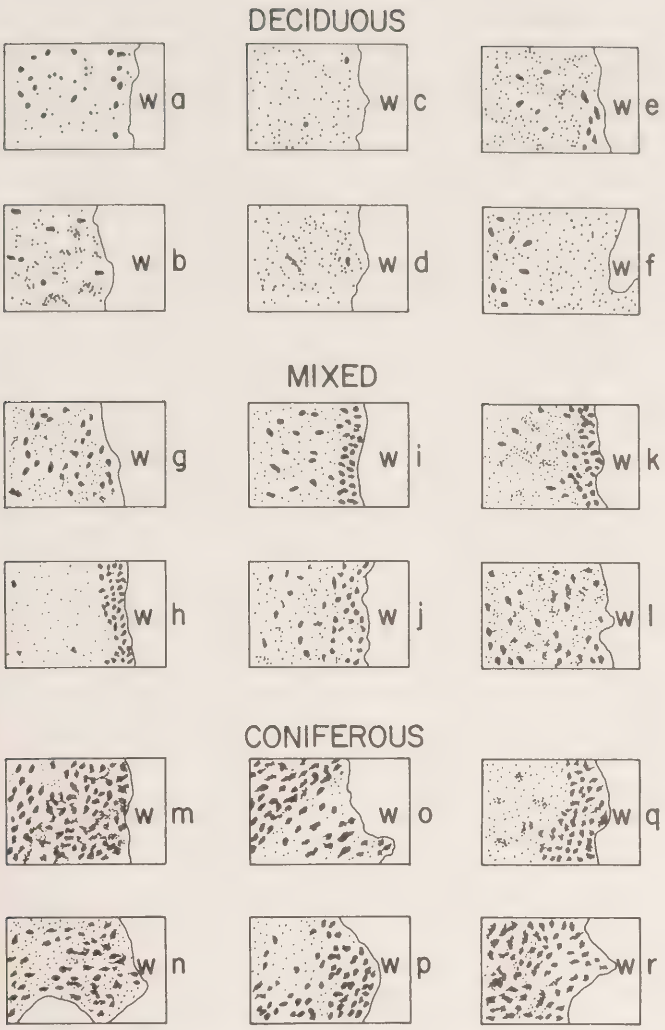


Figure 4. Habitat forest type: deciduous, mixed, coniferous.

proximation of acceptable lot size. Rough values for average lot size in an area of existing and/or proposed development are entered for each segment. For example, if the lots each have a frontage of 100 feet (31 m), the average lot sizes are derived from Table 2 and entered on the Input Data Sheet as .17 for all appropriate segments. Enter zero for segments with no development. LAKELIFE is then run to determine the acceptability of these rough lot sizes. In subsequent runs of LAKELIFE, this rough value can be changed (See Section 3.7) until lot sizes with an acceptable impact are reached. Once an acceptable rough value is obtained, the user may wish to follow through by assessing the acceptability of individual precise lot sizes: see Approach 2.

Table 2. Lot sizes derived from frontage (for Approach 1)

Frontage		LOT SIZE*
Feet	Metres	
50 – 74	15 – 22	.09
75 – 99	23 – 30	.13
100 – 124	31 – 37	.17
125 – 149	38 – 45	.21
150 – 174	46 – 53	.25
175 – 199	54 – 60	.28
200 – 249	61 – 75	.34
250 – 299	76 – 91	.42
300 – 349	92 – 106	.49
350 – 399	107 – 121	.57
400 – 499	122 – 152	.68
500 – 999	153 – 304	1.1
1000 – 1999	305 – 610	2.3
>2000	>610	3.1

*Calculated by multiplying the frontage in metres by 50 m (giving LOT SIZE in hectares) for use in LAKELIFE, assuming a square or rectangular lot.

APPROACH 2

The second approach may be used to evaluate the acceptability of a formal development plan. It may also be used in conjunction with the first approach, where an acceptable rough lot size was attained and individual precise sizes must now be decided. Lot sizes must be calculated for the lots in each segment in the following steps.

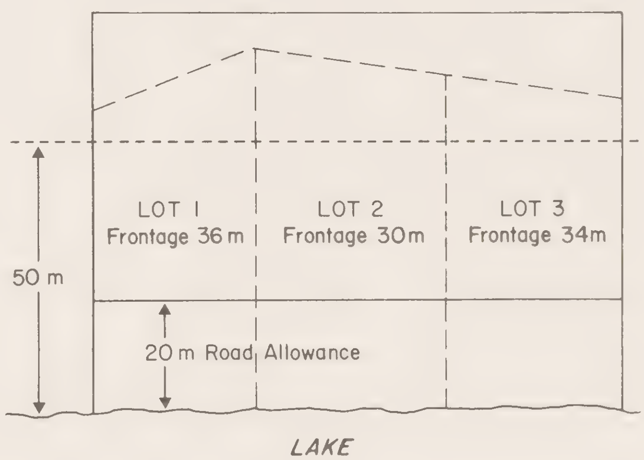
(1) Calculate Individual Lot Sizes (prior to entering on the Input Data Sheet).

The frontage of both existing and proposed lots can be obtained from registered or reference development plan maps. The exact frontage (in metres) is multiplied by 50 m which gives the lot size in square metres. This is converted to hectares by dividing by 10,000.

Where there are no development plans, assign boundaries to the lots at the half-way point between cottages, and calculate the lot size accordingly. If there is only one cottage in a segment, that lot size would be equal to the size of the segment.

(2) Calculate Average Lot Sizes For Each Segment.

(a) If a length of shoreline contains uniform lot sizes and all that length is allocated for lots, the average (arithmetic mean) lot size may be used for each segment in that length of shoreline (Fig. 5).



$$\text{ARITHMETIC MEAN} = \frac{\text{Area lot 1} + \text{Area lot 2} + \text{Area lot 3}}{3}$$

$$= \frac{\left(\frac{36\text{ m} \times 50\text{ m}}{10{,}000}\right) + \left(\frac{30 \times 50}{10{,}000}\right) + \left(\frac{34 \times 50}{10{,}000}\right)}{3}$$

$$= \frac{.18 + .15 + .17}{3}$$

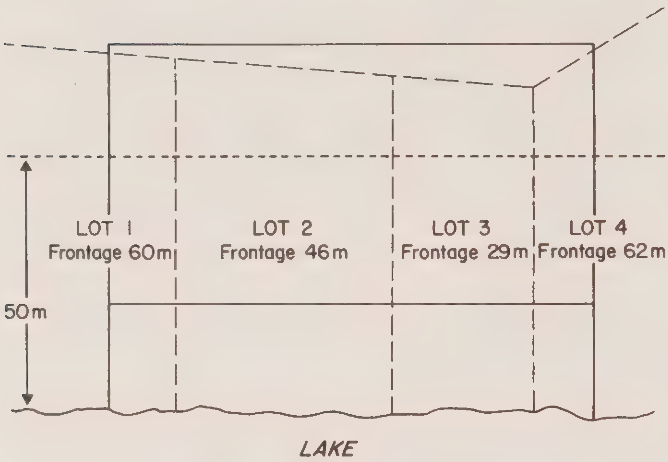
$$= .17\text{ ha}$$

Figure 5. Calculation of average lot size for a segment which contains uniform lot sizes.

(b) If a segment has part of lots of two significantly different lot sizes, then the weighted average lot size should be used (Fig. 6). The weighted average is calculated by multiplying the area of each lot in the segment by the proportion of the segment fronted by that lot.

$$X = \sum_{i=1}^{n} (A_i \times P_i) \qquad (1)$$

where X = weighted average lot size
n = total number of lots located on that segment
i = lot number
A_i = the area of the ith lot
P_i = the proportion of that segment fronted by lot i



$$\text{WEIGHTED AVERAGE} = \sum_{i=1}^{n} (\text{Area of each lot} \times \text{Proportion of segment fronted by that lot})$$
$$= (.30 \times .16) + (.23 \times .46) + (.15 \times .29) + (.31 \times .09)$$
$$= .23 \text{ ha}$$

Figure 6. Calculation of average lot size for a segment which contains parts of significantly different lot sizes.

Lots or undeveloped areas which fall between two segments may be included in either segment's calculations, but not both. It is up to the user's discretion.

(c) If a section of shoreline contains an undeveloped area, this area will be added to the area of the adjoining lot (Fig. 7). Then the average lot size or weighted average is calculated as in (a) or (b).

(d) If the frontage of a lot spans two or more segments, that lot size will be entered onto the Input Data Sheet for both or all segments.

(e) When a resort, park area, public boat launching area, public beach, or farmland is present, the lot size is set at .13 ha. LAKELIFE interprets small lot size values as indicative of intense usage of an area.

G. FILL IN DEER WINTERING AREAS ON INPUT DATA SHEET (DEER YARD).

- OMNR staff at District or Regional Offices can provide locations of most deer concentration areas in the vicinity of proposed developments. When information is not available, a field examination by OMNR staff is required.
- If a segment is partially or completely within a deer wintering area, mark "1" on the Input Data Sheet; otherwise, mark "0".
- A detailed description of deer wintering habitat is available in W.T.R.: 10.

H. ASSIGN LITTORAL ZONE HABITAT TYPE AND FILL IN ON THE INPUT DATA SHEET (LITT. HAB.)

- Existing littoral zone habitat must be determined for each segment by a field survey.
- There are eight habitat types for the littoral zone, each with corresponding code numbers (Table 3).

Table 3. Habitat terms and code numbers for the identification of littoral zone habitat types.

Type	Definition	Code No.
Sand	more than 80% of the substrate covered by small particles less than 10 mm in diameter.	1
Sand and Gravel	20% or more of the substrate covered by particles less than 140 mm in diameter with at least 50% less than 60 mm.	2
Gravel	70% or more of substrate covered by particles less than 100 mm in diameter with at least 10% in the 20-100 mm range.	3
Rock	40% or more of the substrate covered by particles greater than 140 mm in diameter.	4
Cliff	steeply sloping shoreline, usually a rock cliff, extending into the water and dropping off immediately.	5
Shoals	huge flat slabs of rock, more commonly found in non-Canadian Shield lakes; usually limestone in origin.	6
Litter	abundant organic debris such as logs, sticks, twigs, leaves, and decaying plant matter, etc.	7
Weeds	40% or more of the substrate covered by aquatic plants.	8

I. DETERMINE THE NUMBER AND LOCATION OF OFFSHORE AND ONSHORE LOON NESTING SITES AND FILL IN ON THE INPUT DATA SHEET.

- Count the offshore loon nesting sites, and fill in on the Input Data Sheet. An offshore loon nesting site is a small island or bog hummock (a rounded knoll of vegetation or soil within a bog) less than 0.5 ha in size located more than 50 m from the shoreline. At least 75% of loon nests are found in this type of setting. (W.T.R.: 4)
- Identify all of the best available onshore nesting sites (less than 50 m from the shoreline). Enter the total number of sites and the segment number of each in the spaces provided on the Input Data Sheet.
- Select onshore nesting sites using these criteria:
  (1) low wetland areas with mats of floating vegetation, gently sloping shoreline and abundant ground and shrub cover;
  (2) protected areas with relatively shallow water and little wave action;
  (3) islands or bog hummocks less than 50 m from shore.

• If there are no suitable onshore nesting sites, enter "0" on the Input Data Sheet.

J. DETERMINE THE NUMBER AND LOCATION OF SUITABLE HAWK NESTING AREAS AND FILL IN ON THE INPUT DATA SHEET.

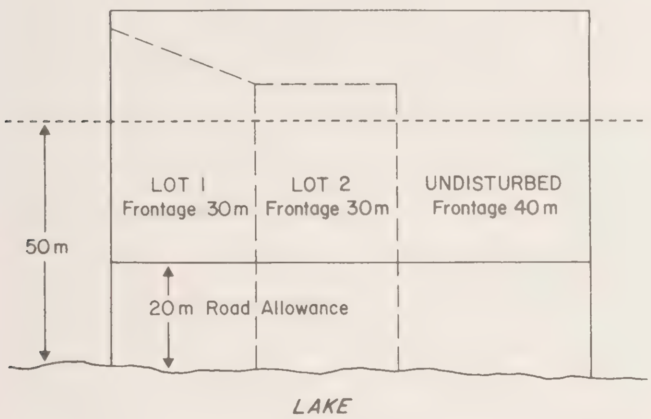
• Identify all of the best broad-winged hawk nesting areas. Enter the total number of sites and the segment number of each in the appropriate spaces on the Input Data Sheet.

• Select sites using these criteria:

(1) a stream valley which may be small and identifiable only from the lake surface (not from an aerial photograph).

(2) there should be 70 to 90% tree cover of which 20% should be close to mature (diameter at breast height greater than 40 cm) and 10 to 30% coniferous (W.T.R.: 6).

• If there are no hawk nesting sites, enter "0" on the Input Data Sheet.



$$\text{ARITHMETIC MEAN} = \frac{\text{Area lot I} + (\text{Area lot 2} + \text{Area undisturbed})}{2} = \frac{.15 + (.15 + .20)}{2} = .25 \text{ ha}$$

$$\text{WEIGHTED AVERAGE} = (\text{Area lot I} \times \text{Proportion lot I}) + [(\text{Area lot 2} + \text{Area undisturbed}) \times \text{Proportion lot 2 undisturbed}] = (.15 \times .30) + [(.15 + .20) \times .70] = .29 \text{ ha}$$

Figure 7. Calculation of average lot size for a segment which contains an undeveloped area.

K. DETERMINE THE NUMBER AND LOCATION OF SUITABLE TURTLE NESTING SITES AND FILL IN ON THE INPUT DATA SHEET.

• Identify all of the suitable turtle nesting sites. Enter the total number of sites and the segment number of each in the spaces provided on the Input Data Sheet.

• Select sites according to these criteria:

(1) sand with little or no vegetative cover;

(2) location less than 200 m from water;

(3) artificial and heavily used public beaches are not suitable nesting sites (W.T.R.: 11).

• If there are no turtle nesting sites, enter "0" on the Input Data Sheet.

L. COUNT STREAMS AND FILL IN THE SEGMENT NUMBER OF EACH ON THE INPUT SHEET.

• Identify all streams on the lake. Enter the total number of streams and the segment number of each in the spaces provided on the Input Data Sheet.

• Streams are any measurable inflow or outflow from a lake which can be identified from an aerial photograph or field survey during the spring season. Most lakes have at least one inflow and outflow.

• If there are two or more streams in the same segment, that segment number must be entered for each stream.

2.3 CHECKING THE DATA

The above steps are the most difficult part of the modelling process. It is imperative that the LAKELIFE Input Data Sheet (Fig. 2) be clear, complete, and correct to avoid wasting computer time (sitting at the computer terminal and doing nothing costs money too!).

It is well worth the planner's time to check for errors at this stage. All the information that the computer will require will be recorded on the Input Data Sheet, so now the planner will be ready for the computer.

---

*W.T.R. = Wildlife Technical Report by Euler et al.

3. USING THE COMPUTER

The following sections outline the steps necessary for starting a terminal session and using the LAKELIFE model.

3.1 BEGINNING THE SESSION

Beginning a session at the computer, or logging on (LOGON Procedure), identifies the user and the account. The user must refer to the System User's Guide[1] provided with the terminal for specific details concerning this procedure, because it varies from terminal to terminal. Once the user is identified, the computer responds with:

READY

3.2 ENTERING THE SEGMENT DATA

The purpose of this step is to input habitat information for each segment into a dataset[2]. First, the user types:

EDIT

and presses Return; the computer responds with:

ENTER DATA SET NAME

The user must then type the eight-character (or less) dataset name followed by ".DATA". The Return key is then pressed. The computer will respond:

DATA SET OR MEMBER NOT FOUND, ASSUMED TO BE NEW.
INPUT
00010

The line number (00010) prompts the user to respond with a line of segment data which looks typically like:

1.2603

where 1 = Habitat type
.26 = Lot size
0 = Deer yard
3 = Littoral zone habitat

Then the user presses the Return key. The computer will respond with another prompt. The user enters a line of data, and this process continues until all segment data have been entered.

1 An alternative is to consult support staff at Wildlife Branch, Queen's Park, Toronto, Ontario.

2 See the Dickie Lake case study, Section 5 and Fig. 8, 9.

The data input is terminated when all segments have been input, and the user presses the Return key, instead of typing a line of data after a prompt. The computer will respond:

EDIT

The user types the subcommand "END SAVE", and presses Return which informs the computer that the dataset is to be kept and the edit mode is to be ended. The computer will type:

READY

Several datasets with different names may be created by following the above series of commands. The user will be able to use any of them in future sessions. Correcting mistakes and/or changing values in datasets is discussed in Section 3.7.

The user may encounter technical problems which do not seem to have an obvious solution. If this occurs, it is advisable to consult support staff or check the System User's Guide.

3.3 USING THE DATASET

The "ALLOCATE" command indicates the desired dataset to be used by LAKELIFE and it is typed by the user exactly as follows.

ALLOCATE FILE(FT10F001) DA(dataset name)

Then the Return key is pressed.

Note: "Dataset name" in this command refers to the eight character name followed by ".DATA" which the user supplied to name the data. Type in the name between the parentheses.

In order to begin the question and answer part of LAKELIFE, the user types:

EXEC LAKELIFE

and presses Return.

3.4 THE QUESTION AND ANSWER PART

Some attention to format at this point will prevent problems later. The answers required by the computer in the question and answer part which follows must be given in a certain format, specified in brackets after the question. For example, I2 means the computer requires a two-digit integer without decimals. Similarly, F5.0 means the computer requires a five-digit number which may or may not contain a decimal. The most important point to remember is that all answers must be right-justified. For example, if the computer requires a three-digit number, and the answer is a two-digit number, the extra space in front of the number must be filled in with a zero:

The number of spaces provided on the Input Data Sheet correspond to the number of digits required by the computer. All the answers required by the computer are already filled out on the Input Data Sheet (Fig. 2). The following are the computer's questions and the required responses.

A. WHAT IS THE DATASET REFERENCE NUMBER? (I2)
The user types "10" from the ALLOCATE statement (see Section 3.3):

10

B. WHAT IS THE NUMBER OF SEGMENTS? (I3)
The user types one three-digit integer. It must occupy the first three spaces of the response line. For example, if there are 75 segments, the response will be:

075

C. WHAT IS THE SEGMENT SIZE (050, 100, or 200 M)? (I3)
The user types one three-digit integer which occupies the first three spaces of the response line. For example, if the segments are 100 m in length, the response will be:

100

D. WHAT IS THE TOTAL LENGTH OF SHORELINE? (I5)
This is typed as a single five-digit number. For example, if the length of shoreline on the lake is 3100 m, the response will be:

03100

E. WHAT IS THE LENGTH OF DEVELOPED SHORELINE? (I5)
This is typed as one five-digit number which occupies the first five spaces of the response line. It includes existing and proposed development. For example, if the total length of developed shoreline is 350 m, the response line will be:

00350

F. WHAT IS THE NUMBER OF LOTS? (I5)
This is typed as one five-digit integer which occupies the first five spaces of the response line. For example, if the total number of cottages is 15, the response will be:

00015

G. WHAT IS THE AREA OF THE LAKE? (F5.1)
This is typed as a four-digit number with one space for the decimal point. For example, if the area of the lake is 45.3 ha, the response will be:

045.3

(Note: The answer fills up the required five spaces.)

H. WHAT IS THE NUMBER OF LOON NEST SITES GREATER THAN 50 m FROM SHORE? (I3)
This is typed as a three-digit number. For example, if the number of loon nesting islands is three, the response will be:

003

I. WHAT IS THE NUMBER OF LOON NEST SITES LESS THAN 50 m FROM SHORE? (I3)
This is typed as a three-digit number. For example, if there are four loon nesting sites less than 50 m from shore, the response will be:

004

J. ENTER SEGMENT FOR LOON NEST SITE NO. X (I3)
This request will be repeated by the computer for each of the loon nest sites, the total number of which was specified by the user in the previous question. The answer is typed as a three-digit number. If LOON NEST SITE NO. 1 is located in segment 32, the response would be:

032

K. WHAT IS THE NUMBER OF HAWK NESTING VALLEYS? (I3)
This is typed as a three-digit number. For example, if there are three potential hawk nesting valleys, the response will be:

003

L. ENTER SEGMENT FOR HAWK NESTING VALLEY NO. X (I3)
This request will be repeated by the computer for each of the hawk nesting sites. The answer is typed as a three-digit integer. For example, if the segment number of HAWK NESTING VALLEY NO. 2 is 45, the response will be:

045

M. WHAT IS THE NUMBER OF TURTLE NESTING SITES? (I3)
This is typed as a three-digit number. For example, if there are four potential turtle nesting sites, the response will be:

004

N. ENTER THE SEGMENT FOR TURTLE NEST SITE NO. X (I3)
This request will be repeated by the computer for each of the turtle nesting sites. For example, if the segment number of TURTLE NESTING SITE NO. 1 is 26, the response will be:

026

O. WHAT IS THE NUMBER OF STREAMS? (I3)
This is typed as a three-digit number. It occupies the first three spaces of the response line. For example, if there are nine segments that contain streams on the lake, the response will be:

009

P. ENTER SEGMENT NUMBER FOR STREAM NO. X (I3)
This request will be repeated by the computer for each of the streams. For example, if the segment number of STREAM NO. 3 is 14, the response will be:

014

3.5 LAKELIFE'S PRINTOUT

All information contained on the LAKELIFE Input Data Sheet will now have been transferred to the computer. It will produce a printout of the model's predictions without prompting.

3.6 PROBLEMS

If, in the preceding session, the computer did not simultaneously respond as indicated above, the data in the question and answer portion was probably entered incorrectly. Check the sheet again to see that the required format was used, and check the input to see that everything was input correctly. If the user discovers an error, he/she may run through the question and answer portion again (once the necessary corrections are made as in Section 3.7) by typing:

```
ALLOCATE FILE(FT10F001) DA(dataset name)
EXEC LAKELIFE
```

The user may get halfway through the question and answer part and wish to begin again, or to interrupt the computer's printout. To do this, the Break key or equivalent may be pressed. The computer will respond with:

```
READY
```

The question and answer part may be started again by typing:

```
ALLOCATE FILE(FT10F001) DA(dataset name)
EXEC LAKELIFE
```

3.7 CHANGING THE VALUES IN THE DATASET

Once the results from the first attempt at modelling have been printed out, some alteration may be necessary. If the model predicts a serious impact on wildlife habitat, some lots may have to be deleted or enlarged. Alternatively, the model may indicate that more development could occur without serious impact. In both these cases, the values of the LOT SIZE variable in the dataset requires alteration. These changes can be made without re-entering the entire dataset. Follow these steps:

- Before any changes are made, the computer must be put into EDIT mode by typing "EDIT" followed by a space and the dataset name.

```
EDIT lakename.DATA
```

- If the user requires a listing of the original dataset, a printout may be obtained by typing:

```
LIST
```

- A single LOT SIZE value may be altered by typing "CHANGE", followed by the line number, followed by question marks before and after the existing value of LOT SIZE, followed by the new value of LOT SIZE. For example, the lot size on line 00070 (which is segment 7) may be changed from .12 to .16 by typing:

```
CHANGE 70 ?.12?.16
```

- If a number of segments have the same LOT SIZE, and the user wishes to change them all to a new value, a one-step command is made. For example, to change all LOT SIZE values for segments 7 to 21 inclusive from .12 to .16, type:

```
CHANGE 70 210 ?.12?.16?ALL
```

- An entire line of data may be changed by typing the line number and the new line of data. For example, if the user wishes to change the data for segment 14 from 1.2901 to 2.1808, the user types:

```
140 2.1808
```

The command "CHANGE" is not typed.
140 refers to line number

4. INTERPRETATION AND EVALUATION OF THE OUTPUT

Interpretation of the results from the first run of the model may show that some alteration to the input is necessary. If the model predicts an unacceptable impact on wildlife habitat, some lots may have to be deleted or enlarged. Alternatively, the model may indicate that more development can occur without serious impact.

The underlined statements in Sections 4.2 to 4.5 enable evaluation of the output and are based on the recommendations of the Wildlife Component of the LCS . In addition, the lake in question should be investigated for endangered and rare species before the development proposal is evaluated. If the species and their habitats are discovered, these areas must be protected.

The output is presented in five sections.

4.1 REVIEW OF INPUT VALUES AND AREA DEVELOPMENT INDEX (ADI) FOR EACH SEGMENT

A presentation of the input values and the associated Area Development Index (ADI) for each segment is the first part of the output. The ADI is discussed in detail in Section 6.1.

4.2 IMPACT VALUES FOR SMALL MAMMALS

Habitat for each of the small mammals should not be allowed to decrease by more than 75%. The impact values represent a Capture Index calculated before and after development (Section 6.2; W.T.R.: 12). If these values decrease by more than 75%, the habitat disturbance would be unacceptable. The cottage lots must be rearranged or modified to reduce the impact.

4.3 IMPACT VALUES FOR LOONS, HAWKS, MINK, DEER, TURTLES AND STREAMS

4.3.1 IMPACT VALUE FOR LOONS

The Loon Nesting Disturbance Value must not be less than 2.0. This implies that in four years out of 10, breeding loons will have a successful nest (i.e. a nest that fledges at least one young) if this value is not less than 2.0 (Section 6.6; W.T.R.: 4).

4.3.2 IMPACT VALUE FOR HAWKS

The Broad-Winged Hawk Nesting Value must not be less than 2.0. At this level or greater, there will be at least two nesting sites available for broad-winged hawks (Section 6.5; W.T.R.: 6).

4.3.3 IMPACT VALUES FOR MINK

The Lake Mink Value after development must not be permitted to fall below one-third of the Lake Mink Value before development. If the post-development level is less than one-third of the pre-development value, modification of the proposed development will be necessary. **The Cottager Loading Development Index (CLDI) must not exceed 1.0.** At this level, the mink population may be sustained. At values greater than 1.0 this may not be possible (Section 6.3; W.T.R.: 8).

4.3.4 IMPACT VALUE FOR DEER

No section of shoreline known to be or have been a deer yard should contain cottage development. If there were any difference in the Lake Deer Yard Value before and after development, the development in that area would be unacceptable (Section 6.7; W.T.R.: 10).

4.3.5 IMPACT VALUE FOR TURTLES

Two turtle nesting sites must not be developed. (Section 6.9; W.T.R.: 6).

4.3.6 IMPACT VALUE FOR STREAMS

Fifty percent of the segments containing streams on a lake must not be developed (Section 6.8; W.T.R.: 11).

4.4 IMPACT VALUES FOR SONGBIRDS

The output for songbirds is given in two parts. The first table shows the change in songbird coefficient of community. **A development is unacceptable if more than 75% of the segments on a lake are altered.** The second table shows available habitat for breeding pairs before and after development. **A decline greater than 75% in the amount of habitat available for breeding songbirds is unacceptable.** In addition to these, a table is also provided which illustrates changes in the number of breeding pairs of each species with development (Section 6.4; W.T.R.: 7).

4.5 IMPACT VALUES FOR LITTORAL ZONE HABITAT OF FIVE FISH SPECIES

Any decrease of more than 30% in the amount of littoral zone habitat, over pre-development levels, for any fish species, is unacceptable. The removal of fish by sport fishing can make, apparently insignificant, littoral zone losses take on new importance. The effects of acid precipitation on fish survival may also be magnified by a reduction in littoral zone habitat (Section 6.10).

4.6 EVALUATION AND IMPROVEMENT OF THE LAKE PLAN

Two basic premises were used to evaluate the acceptability of cottage development.

(1) Wildlife populations on a lake must be maintained in self-sustaining communities that are as similar as possible to undisturbed shoreline communities, on some portions of all lakes but not everywhere on all lakes.

(2) No species can be extirpated from the shoreline community of any lake.

If LAKELIFE indicates that some of the impacts are unacceptable according to our recommendations, the development proposal may be modified by increasing lot sizes, decreasing the number of lots, or by changing their location. The dataset containing the lot size information may be subsequently revised (Section 3.7), or a new dataset may be created (Section 3.2). The model may be executed again after each successive modification to the lake plan (Sections 3.3 to 3.5). When the model indicates that the plan conforms to the recommendations (Sections 4.2 to 4.5; PART I), the process is complete.

To adhere strictly to the minimum standards set by the recommendations, while disregarding the field situation, is not advisable. The planner may have to make decisions based on experience rather than on LAKELIFE results.

If the planner cannot reconcile a problem, biologists from the OMNR District or Region concerned may be able to assist.

5. DICKIE LAKE CASE STUDY

The Dickie Lake Case Study is an actual example of the evaluation of development, using the LAKELIFE model. This highly developed lake is located 2 km east of Baysville in central Ontario. It was studied by most Components of the LCS. The user may wish to go through a trial run, using the Dickie Lake Input Data Sheet before attempting to model another lake. A system of overlays (Appendix D) which show vegetation and proposed development on Blue Chalk Lake, may be used to practice filling out an Input Data Sheet and running LAKELIFE.

5.1 PREPARATION

An enlarged copy (1:5000) of an aerial photograph, taken in a leaf-free, snow-free condition (Fig. 11), was used to obtain most of the habitat information required for the Dickie Lake Input Data Sheet (Fig. 8). The development information came from registered development plan maps from the municipal registry office. The maps provided all the information required to calculate lot size (Section 2.2).

The shoreline of Dickie Lake was divided into 77 segments of 100 m each. The Input Data Sheet was then filled out according to the directions given in Section 2.2. The completed Input Data Sheet is shown in Figure 8.

5.2 USE OF THE COMPUTER MODEL

This case study employed the interactive mode (TSO). The data was input, following the directions given in Sections 3.1 to 3.7. Figure 9 demonstrates the use of LAKELIFE for Dickie Lake, including the inputs keyed in by the user and the output printed by the computer.

Figure 11. A large-scale photograph of Dickie Lake.

LAKELIFE INPUT DATA SHEET

LAKE NAME DICKIE LAKE
DATASET NAME DICKIE.DATA
NO. OF SEGMENTS 077
SEGMENT SIZE (metres) 100
TOTAL LENGTH OF SHORELINE (metres) 07700
TOTAL LENGTH DEVELOPED (metres) 07350
NUMBER OF LOTS 00112
AREA OF LAKE (hectares) 089.2
NO. OF OFFSHORE LOON NESTING SITES (>50 m) 006

NO. OF ONSHORE LOON NESTING SITES (<50 M)	NO. OF HAWK NESTING SITES	NO. OF TURTLE NESTING SITES	NO. OF STREAMS
003	003	002	008

LOON NEST (SEG. NO)	HAWK NEST (SEG. NO.)	TURTLE NEST (SEG. NO.)	STREAMS (SEG. NO.)
030	006	040	001
045	044	041	006
070	062		018
			029
			044
			045
			062
			070

SEG. NO.	HAB. TYPE	LOT SIZE	DEER YARD	LITT. HAB.
1	1	.26	0	3
2	1	.33	0	3
3	1	.55	0	7
4	1	.22	0	4
5	1	.19	0	4
6	1	1.5	0	7
7	1	.17	0	4
8	1	.17	0	4
9	2	.23	0	4
10	1	.23	0	4
11	1	.19	0	4
12	1	.19	0	1
13	1	.22	0	4
14	1	.16	0	7
15	1	.16	0	4
16	1	.19	0	4
17	1	.20	0	4
18	1	.35	0	7
19	3	.50	0	8
20	3	.40	0	4
21	3	.20	0	8
22	3	.16	0	8
23	3	.19	0	8
24	2	.18	0	3
25	2	.17	0	3
26	2	.21	0	3
27	2	.21	0	3
28	2	.16	0	7
29	2	.33	0	8
30	2	.24	0	8
31	2	.15	0	8
32	2	.22	0	7
33	3	.16	0	2
34	3	.16	0	8
35	3	000	0	3
36	3	000	0	3
37	3	5.0	0	3
38	3	5.0	0	3
39	3	5.0	0	3
40	3	5.0	0	3
41	3	000	0	3
42	3	.60	0	1
43	3	.60	0	1
44	3	000	0	3
45	2	000	0	7
46	3	000	0	2
47	3	.15	0	2
48	3	.15	0	3
49	3	.15	0	3
50	3	.16	0	3

SEG. NO.	HAB. TYPE	LOT SIZE	DEER YARD	LITT. HAB.
51	2	.19	0	3
52	3	.19	0	4
53	3	.21	0	3
54	3	.27	0	8
55	3	.27	0	4
56	3	.30	0	4
57	3	.50	0	4
58	3	.50	0	4
59	3	.30	0	4
60	3	.16	0	4
61	3	.17	0	4
62	2	.27	0	8
63	1	.17	0	1
64	1	.17	0	2
65	1	.18	0	3
66	3	.35	0	3
67	1	.15	0	3
68	1	.18	0	3
69	1	.40	0	3
70	3	.25	0	3
71	2	.19	0	3
72	1	.17	0	3
73	1	.22	0	3
74	1	.29	0	3
75	1	.32	0	3
76	1	.42	0	3
77	1	.42	0	3
78				
79				
80				
81				
82				
83				
84				
85				
86				
87				
88				
89				
90				
91				
92				
93				
94				
95				
96				
97				
98				
99				
100				

LAKE NAME Dickie Lake
USER NAME Jan
DATE FILLED OUT October 1981
COMMENTS example for use in LAKELIFE User's Manual

Figure 8. LAKELIFE Input Data Sheet for Dickie Lake Case Study.

5.3 INTERPRETATION OF OUTPUT

The output for Dickie Lake (Fig. 9) was divided into five sections.

```
LOGON
IKJ56700A ENTER USERID -
NRGAEE
ENTER CURRENT PASSWORD FOR NRGAEE-
########
ICH70001I NRGAEE   LAST ACCESS AT 11:39:00 ON 81.239
ENTER ACCOUNT NUMBER -
GA/2125
NRGAEE LOGON IN PROGRESS AT 11:11:11 ON SEPTEMBER 21, 1981
 QPCB TIME SHARING (MVS 3.8C)
 NEWS:  REMINDER - SORT 4.0       (AUG.11)
 NEWS:  SORT 4.0 PROBLEMS RESOLVED        (AUG.13)
 NEWS:  NEW COMMAND - LISTVR     (AUG.25)
 NEWS:  OPTIMIZER III - DELETION OF OLD LIBRARIES  (AUG.27)
DATA SET CLIST NOT IN CATALOG
READY

EDIT
ENTER DATA SET NAME -
ACEY.DICKIE.DATA
DATA SET OR MEMBER NOT FOUND, ASSUMED TO BE NEW
INPUT
00010 1.2603
00020 1.3303
00030 1.5507
00040 1.2204
00050 1.1904
00060 11.507
00070 1.1704
00080 1.1704
00090 2.2304
00100 1.2304
00110 1.1904
00120 1.1901
00130 1.2204
00140 1.1607
00150 1.1604
00160 1.1904
00170 1.2004
00180 1.3507
00190 3.5008
00200 3.4004
00210 3.2008
00220 3.1608
00230 3.1008
00240 2.1803
00250 2.1703
00260 2.2103
00270 2.2103
00280 2.1607
00290 2.3308
00300 2.2408
00310 2.1508
00320 2.2207
00330 3.1602
00340 3.1608
00350 300003
00360 300003
00370 35.003
00380 35.003
00390 35.003
00400 35.003
00410 300003
00420 3.5001
00430 3.6001
00440 300003
00450 200007
00460 300002
00470 3.1502
00480 3.1503
00490 3.1503
00500 3.1603
00510 2.1903
00520 3.1904
00530 3.2103
00540 3.2708
00550 3.2704
00560 3.3004
00570 3.5004
00580 3.5004
00590 3.3004
00600 3.1600
00610 3.1704
00620 2.2708
00630 1.1701
00640 1.1702
00650 1.1803
00660 3.3503
00670 1.1503
00680 1.1803
00690 1.1403
00700 3.2503
00710 2.1903
00720 1.1703
00730 1.2203
00740 1.2903
00750 1.3203
00760 1.4203
00770 1.4203
00780
EDIT
CHANGE 230 ?3.10?3.19
CHANGE 420 ?3.5?3.6
160 3.1604
690 1.4003
END SAVE
READY

ALLOCATE FILE(FT10F001) DA(ACEY.DICKIE.DATA)
READY
EXEC LAKELIFE
WHAT IS THE DATA SET REFERENCE NUMBER? (I2)
10
WHAT IS THE NUMBER OF SEGMENTS? (I3)
077
WHAT IS THE SEGMENT SIZE (050, 100, OR 200 M)?
100
WHAT IS THE TOTAL LENGTH OF SHORELINE? (I5)
07700
WHAT IS THE LENGTH OF DEVELOPED SHORELINE? (I5)
07350
WHAT IS THE NUMBER OF LOTS? (I5)
00112
WHAT IS THE AREA OF THE LAKE? (F5.0)
089.2
WHAT IS THE NUMBER OF LOON NEST SITES GREATER THAN 50 M FROM SHORE? (I3)
006
WHAT IS THE NUMBER OF LOON NEST SITES LESS THAN 50 M FROM SHORE? (I3)
003
ENTER SEGMENT FOR LOON NEST SITE NO. 1  (I3)
030
ENTER SEGMENT FOR LOON NEST SITE NO. 2  (I3)
045
ENTER SEGMENT FOR LOON NEST SITE NO. 3  (I3)
070
WHAT IS THE NUMBER OF HAWK NESTING VALLEYS? (I3)
003
ENTER SEGMENT FOR HAWK VALLEY NO. 1  (I3)
006
ENTER SEGMENT FOR HAWK VALLEY NO. 2  (I3)
044
ENTER SEGMENT FOR HAWK VALLEY NO. 3  (I3)
062
WHAT IS THE NUMBER OF TURTLE NESTING SITES? (I3)
002
ENTER SEGMENT FOR TURTLE NEST SITE NO. 1  (I3)
040
ENTER SEGMENT FOR TURTLE NEST SITE NO. 2  (I3)
041
WHAT IS THE NUMBER OF STREAMS? (I3)
008
ENTER SEGMENT FOR STREAM NO. 1  (I3)
001
ENTER SEGMENT FOR STREAM NO. 2  (I3)
006
ENTER SEGMENT FOR STREAM NO. 3  (I3)
018
ENTER SEGMENT FOR STREAM NO. 4  (I3)
029
ENTER SEGMENT FOR STREAM NO. 5  (I3)
044
ENTER SEGMENT FOR STREAM NO. 6  (I3)
045
ENTER SEGMENT FOR STREAM NO. 7  (I3)
062
ENTER SEGMENT FOR STREAM NO. 8  (I3)
070
************************************
GENERAL INFORMATION ABOUT THE INPUT
************************************
SEGMENT NUMBER   LOT SIZE   DEVELOPMENT INDEX
----------------------------------------------
       1            0.26          1.7520
       2            0.33          1.4188
       3            0.55          0.7629
       4            0.22          1.9782
       5            0.19          2.1657
       6            1.50          0.1080
       7            0.17          2.2991
       8            0.17          2.2991
       9            0.23          1.9191
      10            0.23          1.9191
      11            0.19          2.1657
      12            0.19          2.1657
      13            0.22          1.9782
      14            0.16          2.3682
      15            0.16          2.3682
      16            0.16          2.3682
      17            0.20          2.1015
      18            0.35          1.3370
      19            0.50          0.8723
      20            0.40          1.1551
      21            0.20          2.1015
```

22	0.16	2.3682
23	0.19	2.1657
24	0.18	2.2316
25	0.17	2.2991
26	0.21	2.0390
27	0.21	2.0390
28	0.16	2.3682
29	0.33	1.4188
30	0.24	1.8617
31	0.15	2.4389
32	0.22	1.9782
33	0.16	2.3682
34	0.16	2.3682
35	0.0	0.0
36	0.0	0.0
37	5.00	0.0
38	5.00	0.0
39	5.00	0.0
40	5.00	0.0
41	0.0	0.0
42	0.60	0.6699
43	0.60	0.6699
44	0.0	0.0
45	0.0	0.0
46	0.0	0.0
47	0.15	2.4389
48	0.15	2.4389
49	0.15	2.4389
50	0.16	2.3682
51	0.19	2.1657
52	0.19	2.1657
53	0.21	2.0390
54	0.27	1.6997
55	0.27	1.6997
56	0.30	1.5524
57	0.50	0.8723
58	0.50	0.8723
59	0.30	1.5524
60	0.16	2.3682
61	0.17	2.2991
62	0.27	1.6997
63	0.17	2.2991
64	0.17	2.2991
65	0.18	2.2316
66	0.35	1.3370
67	0.15	2.4389
68	0.18	2.2316
69	0.40	1.1551
70	0.25	1.9060
71	0.19	2.1657
72	0.17	2.2991
73	0.22	1.9782
74	0.29	1.5999
75	0.32	1.4619
76	0.43	1.[illegible]
77	0.42	1.[illegible]

ORIGINAL INPUT PARAMETERS

NUMBER OF SEGMENTS 77
SEGMENT SIZE 100
TOTAL LENGTH OF SHORELINE (M) .... 7700.
LENGTH OF SHORELINE DEVELOPED 7350
AREA OF THE LAKE 89.2
NUMBER OF COTTAGE LOTS 112
NO. OF LOON NESTING ISLANDS............. 6

LOON NEST SITE NO. 1.................. 30
LOON NEST SITE NO. 2.................. 45
LOON NEST SITE NO. 3.................. 70
HAWK NEST VALLEY NO. 1............... 6
HAWK NEST VALLEY NO. 2............... 44
HAWK NEST VALLEY NO. 3............... 62
TURTLE NEST SITE NO. 1............... 40
TURTLE NEST SITE NO. 2............... 41
STREAM HABITAT NO. 1.................. 1
STREAM HABITAT NO. 2.................. 6
STREAM HABITAT NO. 3.................. 18
STREAM HABITAT NO. 4.................. 29
STREAM HABITAT NO. 5.................. 44
STREAM HABITAT NO. 6.................. 45
STREAM HABITAT NO. 7.................. 62
STREAM HABITAT NO. 8.................. 70

OUTPUT OF ENTIRE LAKE VALUES FOR SMALL MAMMALS

ANIMAL	BEFORE	AFTER	% CHANGE
MA SHREW	145.6	34.4	-76.0
ST SHREW	198.2	339.6	71.4
CHIPMUNK	695.3	1772.9	154.9
R SQUIRL	149.0	185.[illegible]	24.3
DE MOUSE	3428.9	1851.5	-46.0
R B VOLE	3089.4	1030.7	-66.6
WJ MOUSE	410.2	77.7	-81.1

LAKE VALUES

LOON NESTING DISTURBANCE VALUE.......... 6.0
BROAD-WINGED HAWK NESTING VALUE......... 1.0
LAKE MINK VALUE BEFORE DEVELOPMENT...... 2163.
LAKE MINK VALUE AFTER DEVELOPMENT....... 706.
COTTAGER LOADING DEVELOPMENT INDEX...... 1.4
LAKE DEER YARD VALUES BEFORE DEVELOPMENT 0.
LAKE DEER YARD VALUES AFTER DEVELOPMENT 0.
NUMBER OF TURTLE NESTING SITES 0
PERCENT OF STREAM HABITATS DEVELOPED .. 62.5

SONGBIRD COEFFICIENT OF COMMUNITY

NO. OF SEGMENTS ALTERED...... 66
NO. OF SEGMENTS ON LAKE...... 77
% OF SEGMENTS ALTERED........ 85

BIRD HABITAT AVAILABILITY AND NUMBER OF BREEDING PAIRS
BEFORE AND AFTER DEVELOPMENT (CALCULATED FOR THE ENTIRE LAKE)

HABITAT AVAILABLE BEFORE DEVELOPMENT (HECTARES)

BIRD SPECIES	TOTAL*	UNDISTURBED (DI=0)	SOME DISTURBANCE (0<DI<0.35)	DISTURBED (DI 0.35)
OVENBIRD	77	77	0	0
BLTHBLUE	77	77	0	0
BTHGREEN	77	77	0	0
COWBIRD	0	0	0	0
EW PEWEE	0	0	0	0
CANWARBL	49	49	0	0
SWTHRUSH	49	49	0	0
NWTHRUSH	77	77	0	
REVIRED	28	28	0	
GCFLYCAT	49	49	0	
MOURNWAR	49	49	0	
BCREEPER	77	77	0	
WDTHRUSH	77	77	0	
WINTWREN	49	49	0	
ROBIN	0	0	0	0
PHOEBE	0	0	0	0
SONGSPAR	0	0	0	0
YELRUMPW	49	49	0	0
CHIPSPAR	0	0	0	

HABITAT AVAILABLE AFTER DEVELOPMENT (HECTARES)

BIRD SPECIES	TOTAL*		UNDISTURBED (DI=0)	SOME DISTURBANCE (0<DI<0.35)	DISTURBED (DI ...)
OVENBIRD	30		10	20	
BLTHBLUE	10	>75%LOSS	10	0	
BTHGREEN	10	>75%LOSS	10	0	
COWBIRD	71		4	34	
EW PEWEE	14		0	0	14
CANWARBL	30		10	20	0
SWTHRUSH	30		10	20	0
NWTHRUSH	10	>75%LOSS	10	0	
REVIRED	48		0	34	14
GCFLYCAT	6	>75%LOSS	6	0	0
MOURNWAR	6	>75%LOSS	6	0	0
BCREEPER	6	>75%LOSS	6	0	0
WDTHRUSH	6	>75%LOSS	6	0	
WINTWREN	10	>75%LOSS	10	0	
ROBIN	53		0	20	
PHOEBE	67		0	34	
SONGSPAR	47		0	14	[illegible]
YELRUMPW	44		10	34	0
CHIPSPAR	48		0	34	14

* THE STATEMENT - >75%LOSS - INDICATES THAT THE WILDLIFE COMPONENT RECOMMENDATION ABOUT MAINTAINING BIRD HABITAT HAS BEEN VIOLATED. COTTAGE LOTSIZE AND OR LOCATION MUST BE MODIFIED.

NUMBER OF BREEDING BIRD PAIRS BEFORE AND AFTER DEVELOPMENT

BIRD SPECIES	BEFORE DEVELOPMENT	AFTER DEVELOPMENT	IMPACT
OVENBIRD	61.4	[illegible].9	NEGATIVE
BLTHBLUE	[illegible]	10.4	NEGATIVE
BTHGREEN	[illegible]	10.4	NEGATIVE
COWBIRD	[illegible]	[illegible].0	POSITIVE
EW PEWEE	5.6	14.0	POSITIVE
CANWARBL	4.2	.6	NEGATIVE
SWTHRUSH	19.6	5.6	NEGATIVE
NWTHRUSH	[illegible]	11.4	NEGATIVE
REVIRED	[illegible]	56.	POSITIVE
GCFLYCAT	[illegible].4	0.4	NEGATIVE
MOURNWAR	1.[illegible]	0.1	
BCREEPER	[illegible]	0.1	NEGATIVE
WDTHRUSH	1.[illegible]	0.1	
WINTWREN	24.5	5.8	NEGATIVE
ROBIN	0.0	39.4	POSITIVE
PHOEBE	0.0	14.0	POSITIVE
SONGSPAR	[illegible]	[illegible].6	POSITIVE
YELRUMPW	[illegible]	25.4	NEGATIVE
CHIPSPAR	0.0	24.5	POSITIVE

* -IMPACT- REFERS TO THE EXPECTED CHANGE IN ABUNDANCE CAUSED BY DEVELOPMENT

LITTORAL ZONE HABITAT PARAMETERS
****
PUMKINSEED HABITAT

HABITAT TYPE	BEFORE	AFTER
SPAWNING GROUNDS	222.0	222.0
NURSERY GROUNDS	148.0	148.0
FEEDING GROUNDS	280.0	280.0

YELLOW PERCH HABITAT

HABITAT TYPE	BEFORE	AFTER
SPAWNING GROUNDS	53.0	53.0
NURSERY GROUNDS	110.0	110.0
FEEDING GROUNDS	244.0	244.0

ROCK BASS HABITAT

HABITAT TYPE	BEFORE	AFTER
SPAWNING GROUNDS	158.0	158.0
NURSERY GROUNDS	157.0	157.0
FEEDING GROUNDS	109.0	109.0

LM BASS HABITAT

HABITAT TYPE	BEFORE	AFTER
SPAWNING GROUNDS	1[illegible].0	13.0
NURSERY GROUNDS	[illegible]	[illegible]
FEEDING GROUNDS	214.0	[illegible]14.

SM BASS HABITAT

HABITAT TYPE	BEFORE	AFTER
SPAWNING GROUNDS	80.0	80.0
NURSERY GROUNDS	111.0	111.0
FEEDING GROUNDS	122.0	122.0
LOAFING GROUNDS	212.0	212.0

PROGRAM TERMINATED NORMALLY

THANK YOU FOR USING LAKELIFE!
READY

Figure 9. Output for Dickie Lake Case Study.

5.3.1 VERIFICATION OF INPUT VALUES

Values of the input checked against the Input Data Sheet confirmed that all the input had been keyed in correctly. Note that the ADI was 0 in 10 of 77 segments in the post-development state.

5.3.2 OUTPUT FOR SMALL MAMMALS

After development, the Capture Index increased in value for three species after development and decreased for four. Note that a decrease of 75% or more in this Index for any species after development is considered unacceptable. Therefore, the amount of habitat available for masked shrews *(Sorex cinereus)* (−76.0%) and woodland jumping mice *(Napaeozapus insignis)* (−81.1%) has decreased beyond the limits of acceptability.

5.3.3 OUTPUT FOR LOONS, HAWKS, MINK, DEER, TURTLES AND STREAMS

- **Loons:** The Loon Nesting Disturbance Value of 6.0 is greater than the acceptable value of 2.0, suggesting that adequate loon nesting sites would remain after development.
- **Broad-Winged Hawks:** The Broad-Winged Hawk Nesting Value of 1.0 was less than the acceptable limit of 2.0. This suggests that all potential hawk nesting sites identified on the Input Data Sheet were encroached upon by cottage development.
- **Mink:** The Lake Mink Value decreased from 2163 to 706 after development, a decrease of about 67%. According to this criteria, the level of development was marginally acceptable for mink. However, the CLDI had a value of 1.4, which is greater than the acceptable value of 1.0. Because these results conflict, the decision on acceptability of the development plan must depend upon index values for other species.
- **Deer:** Since no deer yards were found on Dickie Lake, the Lake Deer Yard Value was 0 before and after development.
- **Turtles:** The model predicted that no turtle nesting sites remain after development on Dickie Lake. This is unacceptable; it is recommended that two sites be preserved on each lake.
- **Streams:** LAKELIFE calculated that 62.5% of the segments containing streams were developed on Dickie Lake. This exceeded the acceptable limit of 50%.

5.3.4 OUTPUT FOR SONGBIRDS

LAKELIFE predicted an 85% change in the Coefficient of Community, which exceeds the acceptable limit of 75%. LAKELIFE also predicted an increase in available habitat for seven species: cowbird *(Molothrus ater)*, eastern wood pewee *(Contopus virens)*, red-eyed vireo *(Vireo olivaceus)*, robin *(Turdus migratorius)*, phoebe *(Sayornis phoebe)*, song sparrow *(Melospiza melodia)*, and chipping sparrow *(Spizella passerina)*, and a decrease in available habitat for the other 12 species. The black-throated blue warbler *(Dendroica caerulescens)*, black-throated green warbler *(Dendroica virens)*, northern waterthrush *(Seiurus noveboracensis)*, great crested flycatcher *(Myiarchus crinitus)*, mourning warbler *(Oporornis philadelphia)*, brown creeper *(Certhia familiaris)*, wood thrush *(Hylocichla mustelina)* and winter wren *(Troglodytes troglodytes)* would experience an unacceptable loss of available habitat (greater than 75%). The third part of the output predicts the impact of development on the number of breeding pairs.

6. A GENERAL DESCRIPTION OF THE MODEL

LAKELIFE predicts the effect of proposed cottage developments on wildlife by calculating one or more indices for each species or group of species. Some of these are dependent on estimates of certain vegetation parameters shown to change with development; others are dependent upon the Area Development Index (ADI). The following sections explain the calculations done by LAKELIFE and the assumptions used.

6.1 THE AREA DEVELOPMENT INDEX (ADI)

The ADI is presented for each segment in the first portion of the output. It is calculated from the lot size information for each segment. The ADI is an estimate of the degree of habitat disturbance, and is necessary for the prediction of changes in the shoreline wildlife community (W.T.R.: 2). The ADI ranges in value from 0.0 (totally undeveloped) to 3.0 (totally developed).

6.2 SMALL MAMMALS

The Small Mammal Index Values are Capture Indices (W.T.R.: 9), which indicate the quality and quantity of habitat along the lake shoreline. The computer calculates these values (pre- and post-development) by using a two-step procedure. The first step is to estimate the changes in vegetation with development, based on the ADI. In the second step, multiple regression equations are used to calculate the Small Mammal Index Values, using the vegetation parameters from the first step as independent variables. Different equations are used for each of the three habitat types (deciduous, coniferous, and mixed).

LAKELIFE calculates index values for the following species: masked shrew, shorttail shrew *(Blarina brevicauda)*, eastern chipmunk *(Tamias striatus)*, red squirrel *(Tamiasciurus hudsonicus)*, deer mouse *(Peromyscus maniculatus)*, Boreal redback vole *(Clethrionomys gapperi)*, and woodland jumping mouse (W.T.R.: 9).. For each species, the simulation calculates pre- and post-development index values and the percent difference. Large index values indicate good habitat and therefore higher wildlife utilization.

6.3 MINK

Lake Mink Index Values are predicted from the relationship depicted in Figure 10. The Area Development Index and habitat type are used to estimate a relative measure of the potential for mink activity (W.T.R.: 8) before and after development. Another index, the Cottager Loading Development Index (CLDI), is also calculated by LAKELIFE. The potential for mink activity is considered low if the CLDI is greater than 1.0.

6.4 SONGBIRDS

One important consideration relating to songbirds (and all the other wildlife species considered in LAKELIFE), is the con-

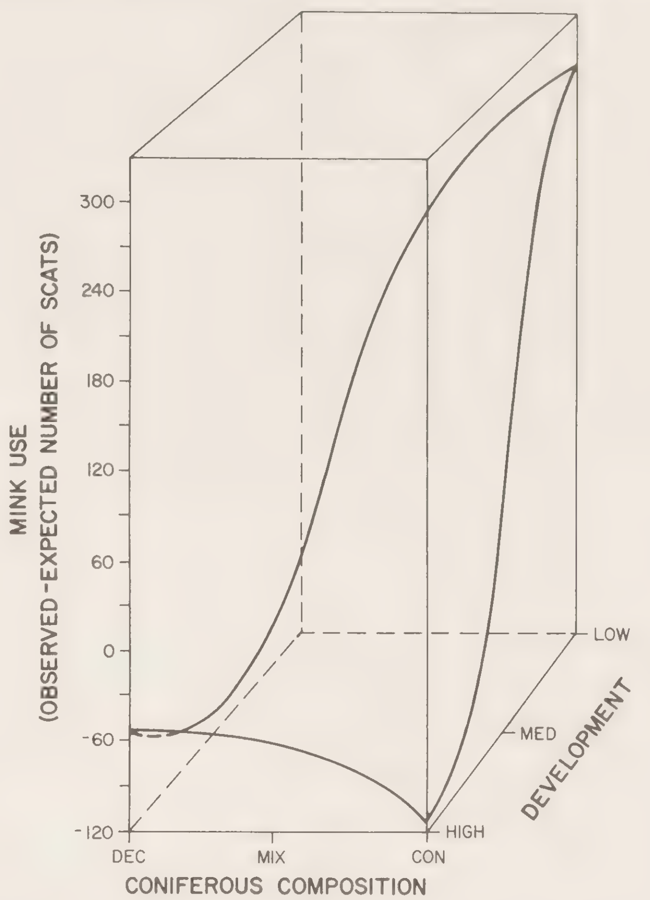


Figure 10. Mink response to development and habitat type.

cept of "community". In other words, the concern is with the overall change in the structure of the bird community, rather than the fate of individual bird species. The songbird community was defined here as an association of bird populations which occur along shorelines within 100 m of a lake. (This cut-off point of 100 m is arbitrary.)

The Coefficient of Community is a good indicator of lakewide impact on the bird community. This coefficient depends on the change in bird species caused by development (Eq. 4 in Part I and, W.T.R.: 7). The calculation is made for each segment on the lake. A segment is considered significantly altered if there is a change in the coefficient of more than 10% for that segment. In keeping with the criteria set in the recommendations, the proportion of segments altered must not exceed 75%.

The 19 bird species presented in the output were studied as identifiers of good songbird habitat. One purpose of LAKELIFE is to allow the planner to determine the overall changes in bird populations which would occur with development to plan for the preservation of their habitat. This allows the maintenance of each of the 19 species. By assessing these indicator species and preventing unacceptable losses, the

original community structure will be represented on a lakeshore. Three assumptions have been made in order to calculate the changes in habitat. They are:

(1) that vegetation type determines songbird habitat (vegetation is classified as deciduous or mixed/coniferous);
(2) that forest edge created by cottage development affects songbird community structure and composition in addition to the disturbance itself, and;
(3) that changes in edge and other environmental factors associated with cottage development are correlated with changes in the ADI.

The ADI can be used to estimate the extent of habitat disturbance on a segment of shoreline. Three levels of ADI are meaningful: undisturbed (ADI = 0), moderate disturbance ($0 < ADI < 1.05$), and high disturbance ($ADI > 1.05$).

In order to convert habitat values to number of breeding pairs of birds on a lake, one additional assumption was made.

(4) The probability of a bird species occurring on a particular segment of shoreline is proportional to the frequency of occurrence of bird species on a shoreline reported in the field studies (W.T.R.: 3). This is dependent on the vegetation type and level of disturbance. The number of breeding pairs is calculated as the sum of probabilities for a series of segments on a lake and is given by:

$$\text{Number of Breeding Pairs} = \sum_{i=1}^{n} P_i \qquad (2)$$

where P = probability of a bird pair occurring, given a particular vegetation type and level of disturbance.
i = segment number
n = number of segments

6.5 BROAD-WINGED HAWKS

Generally, suitable broad-winged hawk nesting sites are valleys dominated by yellow birch *(Betula alleghaniensis)* or maple *(Acer* spp.) (W.T.R.: 6). A small stream should be present. The forest should be at least 70 years old.

The Broad-Winged Hawk Nest Disturbance Value can range from 0.0 up to the number of sites input by the user. This value is equivalent to the number of potential hawk nesting sites which would remain once development has taken place.

6.6 COMMON LOONS

Loon reproduction is negatively affected by cottage development (W.T.R.: 4). This may be attributed to two factors: development around nesting areas, and cottager activity on the lake surface. The latter is generally dependent on the total number of cottages on the lake. The assumption is made that loon nesting success decreases with increased activity on the lake surface.

It must be insured that loons have the possibility of nesting successfully on their island nesting sites or on one of the shoreline nesting sites requested as input to the model. If there are loon nesting islands (W.T.R.: 4), it is assumed that the loons will nest there. A loon nesting island is an island less than 0.5 ha located more than 50 m from the shoreline. An island of this size which is less than 50 m from shore is considered a shoreline nesting site. If there is no human activity on the lake surface, it is assumed that any nesting attempts on islands would be successful.

The Loon Nesting Disturbance Value is equivalent to the number of potential onshore loon nesting sites (less than 50 m from shore) which would remain once development has taken place, added to the number of offshore loon nesting sites (greater than 50 m from shore).

6.7 WHITE-TAILED DEER

Winter habitat requirements of white-tailed deer are often met in shoreline areas which contain bands of coniferous cover as well as in backshore areas. Little is known of the dynamics of deer populations in winter concentration areas. It has been established by OMNR that Central Ontario's deer population is presently very low. Therefore, it is critical that shoreline winter concentration areas be preserved for these animals to use.

Coniferous areas on a lakeshore contained within winter concentration areas provide continuous overhead and vertical cover which is needed for protection from wind, deep snow, and cold temperatures. These areas are excellent night bedding sites and travel lanes (W.T.R.: 10). Development in these areas disrupts the continuity of the shelter and reduces its suitability for deer.

6.8 TURTLES

One of the factors limiting the reproductive success of any turtle species on a lake is the availability of adequate nesting areas. It is ironic that development (in the form of man-made sandy beaches) frequently creates excellent turtle egg-laying sites, but human disturbance reduces hatching success in these newly-created areas (W.T.R.: 11). Therefore, the user of LAKELIFE must identify natural turtle nesting sites for preservation. The sites should have reduced vegetative cover and canopy closure as well as shallow soil, good drainage, and a southern exposure.

6.9 STREAM HABITATS

A stream is a measurable inflow or outflow from a lake, which may be present only in the spring. Streams provide important breeding sites for amphibians, nesting areas for broad-winged hawks, and frequently contain shoreline loon nesting sites. They also provide valuable feeding and shelter areas and travel lanes for many wildlife species. Therefore, streams are considered critical habitat.

6.10 LITTORAL ZONE

The littoral zone provides the life requirements for most fish species: spawning sites, nursery grounds, and feeding and loafing areas. The fish species which were numerous in the study lakes were the yellow perch *(Perca flavescens)*, rock bass *(Ambloplites rupestris)*, pumpkinseed *(Lepomis gibbosus)*, largemouth bass *(Micropterus salmoides)*, and smallmouth bass *(M. dolomieui)*. The life requirements for these species are provided by eight littoral zone habitat types (Table 3). Each of these habitat types has some value in the undeveloped state to each fish species. However, the value of each habitat type changes with development. For largemouth bass, weedbeds are the most important feeding areas. Weedbeds are changed by development through the removal of aquatic macrophytes and the formation of sand beaches. This altera-

tion of habitat greatly reduces the value of that section of shoreline as a largemouth bass feeding area. The relationships used to describe the changes in habitat types due to development and the resulting influence on the five candidate fish species are defined by Harker[1]. The independent variable upon which these relationships depend is the index of development, expressed as the number of cottages on a 200 m section of shoreline.

---

1 Harker, J.M. 1981. Littoral Zone Report, Fisheries Component, Lakeshore Capacity Study. Ont. Min. of Nat. Res. (Unpublished report).

7. APPENDIX

APPENDIX A
BATCH PROCESSING: AN ALTERNATIVE

If desired, LAKELIFE can be used with cards. The card deck is constructed using the LAKELIFE User's Manual as described for an interactive session, except that each user response is keypunched onto cards. The following is the deck setup. Check with support staff for the correct information on the first two cards.

```
//JOB NAME JOB (AA/XXXX), 'YOURNAME AND
PHONE', CLASS=A,
// USER=USERID, PASSWORD=SECRET
//STEP1 EXEC FTGICLG, REGION=200K
//FORT.SYSIN DD DSN=LAKELIFE.FORT,DISP=OLD
//GO. SYSIN DD *
```

•
•
•
•

On each card, keypunch the response for one question from the LAKELIFE User's Manual (Section 3.4), using the format described in that section.

•
•
•
•

After the question and answer part, place the deck of cards describing the segment data. Use one card per segment with the format described in LAKELIFE User's Manual (Section 3.2.).

•
•
•
•

End of segment data.

```
/*
//
```

APPENDIX B
DEFINITIONS OF HABITAT AND COMPUTER TERMS

Vegetation	Definition
Coniferous fringe:	A fringe of evergreen vegetation adjacent to the shoreline greater than 5 m wide and independent of the backshore vegetation.
Dominance:	The apparent tendency of one tree *type* (not species) to be the controlling influence upon the vegetative environment.
Deciduous-dominated:	Deciduous trees appear to act as the controlling influence on the vegetation.
Mixed:	Neither coniferous-dominated nor deciduous-dominated.

Computer Messages and Commands	Definition
READY	A message from the system that informs the user that the system is ready to accept a new command.
EDIT	A command that the user gives to create or modify a dataset. This command can be used to input new data or change values in an existing dataset.
CHANGE	A subcommand of EDIT that informs the system of a change in one line or a series of lines in the dataset.
LIST	A subcommand of EDIT that prints out the dataset for viewing purposes.
END	A subcommand of EDIT that informs the system that no further changes are to be made to the dataset. The END subcommand terminates the EDIT mode.
SAVE	A subcommand of EDIT that causes the new or modified dataset to be saved and catalogued by the system for later use.
ALLOCATE	A command that informs the system that you wish to use a certain dataset. In effect, it calls this dataset from storage for immediate use.
EXEC	A command which, when followed by "LAKELIFE", invokes the LAKELIFE program to start requesting the user for information.

APPENDIX C
LAKELIFE MNEMONICS

1. SMALL MAMMALS

CHIPMUNK	Eastern Chipmunk
DE MOUSE	Deer mouse
MA SHREW	Masked shrew
RB VOLE	Boreal redback vole
R SQUIRL	Red squirrel
ST SHREW	Shorttail shrew
WJ MOUSE	Woodland jumping mouse

2. SONGBIRDS

BCREEPER	Brown creeper
BLTHBLUE	Black-throated blue warbler
BTHGREEN	Black-throated green warbler
CANWARBL	Canada warbler
CHIPSPAR	Chipping sparrow
COWBIRD	Cowbird
EWPEWEE	Eastern wood pewee
GCFLYCAT	Great crested flycatcher
MOURNWAR	Mourning warbler
NWTHRUSH	Northern water thrush
OVENBIRD	Ovenbird
PHOEBE	Eastern phoebe
REVIREO	Red-eyed vireo
ROBIN	American robin
SONGSPAR	Song sparrow
SWTHRUSH	Swainson's thrush
WDTHRUSH	Wood thrush
WINTWREN	Winter wren
YELRUMPW	Yellow-rumped warbler

3. FISH

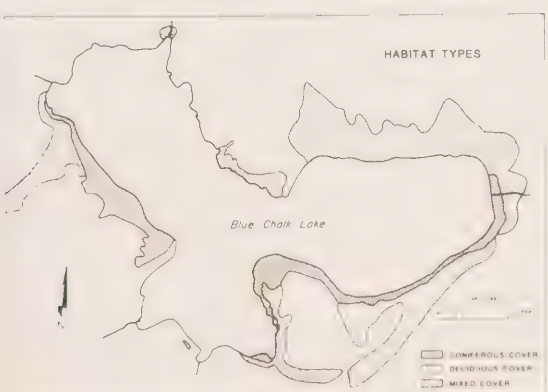
LM BASS	Largemouth bass
PUMKINSEED	Pumpkinseed
ROCK BASS	Rock bass
SM BASS	Smallmouth bass
YELLOW PERCH	Yellow perch

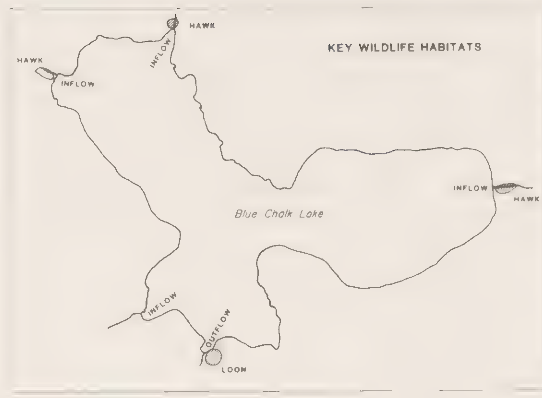
4. MISCELLANEOUS

ADI	Area Development Index
CLDI	Cottager Loading Development Index
DEER YARD	Deer yard capability
HAB TYPE	Habitat type
LCS	Lakeshore Capacity Study
LITT HAB	Littoral zone habitat
LOT SIZE	Average lot size
NO OF LOTS	Number of lots
OMNR	Ontario Ministry of Natural Resources
TSO	Time Sharing Option

APPENDIX D
BLUE CHALK LAKE: AN EXAMPLE WHICH MAY BE USED IN PRACTICE RUNS OF LAKELIFE

The overlays show vegetation, existing development, proposed development, and areas of biological significance. All the information required to fill out an Input Data Sheet (Fig. 2) is on these overlays.





8. GLOSSARY

DEFINITION OF TERMS USED IN PART I AND II OF THIS REPORT.

ADJACENCY: Nearness.

ALKALINE: Any substance which is basic or an hydroxide soluble in water and capable of neutralizing acids.

AMPHIBIANS: Class of cold-blooded vertebrates (includes salamanders, frogs and toads) with most skin; eggs unprotected by a shell and usually there is an aquatic immature stage; may be terrestrial or found in fresh water, but never found in dry habitats.

ANNUALS: Plants which live for only one growing season.

ANTICLINE: In geology, a fold of stratified rock from the crest of which the strata slope downward in opposite directions.

ARCHAEN ROCK: In geology, the oldest known rock.

ASPECT: A facing in a given direction; exposure i.e. the eastern aspect of a house.

AVIAN: Pertaining to birds.

AVIAN COMMUNITY STRUCTURE: Referring to the different species of interacting birds and their numbers which may be found in a particular area.

BACKSHORE COTTAGE DEVELOPMENT: Cottages built around the perimeter of a lake, but having no actual lakeshore frontage; may have a group access point to the lakeshore.

BEDROCK: Solid rock beneath the soil and superficial rock.

BEHAVIOURAL PLASTICITY: The ability to adjust one's behaviour to meet changes in environment.

BENTHOS: Collectively, all those animals and plants living on the bottom of a lake or sea, from the water's edge to greatest depths; the term is often used with reference to animals only.

BIOMASS: Total weight of all organisms in a particular habitat or area; the term is also used to designate the total weight of a particular species or group of species.

BOG: Wet, spongy ground usually covered in mosses such as *Sphagnum* sp., sedges, and heaths.

BOREAL FOREST: Northern forest region.

BROWSE: Twigs, leaves, and shoots of trees or shrubs which animals feed on.

BROWSE UNITS: A measure of the amount of browse available in a specific area; number of living stems and branches with tips less than 2.0 m from the ground multiplied by the percent of coniferous and deciduous stems that were browsed.

BRUNISOL: Referring to a particular type of soil.

BUFFERING CAPACITY: The ability of a lake to dampen or lessen the change in hydrogen ion concentration when an acid or base is added to the solution.

BUTEO: Nearly cosmopolitan genus of large soaring hawks with broad wings and broad, rounded tails.

CANONICAL VARIABLE: A multivariate variable.

CANOPY: The high overhead covering provided by trees.

CANOPY CLOSURE: A measure of the amount of sky which is obscured by trees.

CENTRAL ONTARIO: That area of the province of Ontario lying north of Barrie and south of North Bay which is part of the Great Lakes — St. Lawrence Forest Region; Muskoka and the Haliburton Highlands lie within central Ontario.

CERVIDS: Includes deer, elk, moose, caribou, etc.; males have solid calcareous antlers which are shed and grown anew each year.

CHI SQUARE ANALYSIS: Statistical technique investigating the deviations of the observed numbers from those specified by the hypothesis.

CHLORDANE, OXY., X AND Y: An organochlorine pesticide used mainly to control soil pests; X and Y are isomers of chlordane, while oxychlordane is a break-down product; chlordane is not readily accumulated in warm-blooded animals.

CLAY: A firm, plastic, fine-grained earth, chiefly aluminum silicate; it is produced by the deposit of fine rock particles in water.

CLUSTER SAMPLING: The statistical approach in which the sampling unit consists of some natural group (i.e. a school) formed from the smaller units in which we are interested (the children).

CLUTCH: A nest of eggs; brood of young birds.

COEFFICIENT OF COMMUNITY: A very simple mathematical expression for the similarity of plant or animal communities.

COMMUNITY: Collectively, all of the organisms inhabiting a common environment and interacting with each other.

COMPETITIVE SPECIES: Species which compete with each other for the necessities of life i.e. food, shelter.

CONIFEROUS FOREST: Forest consisting chiefly of evergreen trees such as cedar, hemlock, pines, spruces, etc.

CONTINUUM: A thing whose parts can not be separated or separately discerned; a continuous whole, quantity, or series.

CONVECTIVE HEAT LOSS: Giving off body heat into the surrounding air.

CORRELATION COEFFICIENT: The quantity "r" between X and Y; the strength of the linear relationship between X and Y.

COSMOPOLITAN: Having essentially a world-wide distribution, wherever a suitable habitat occurs; the term refers to the geographical range of a taxon.

COVER-MAP: A map diagrammatically showing the locations of particular vegetation types on a study plot.

CRUSTACEANS: One of the eight classes in the Phylum Arthropoda; includes water fleas, crayfish, lobsters, crabs, barnacles, etc.

CULL LOGS: Logs which have been selectively harvested because they may not have been up to standard.

DAY BEDDING AREA: An open area usually on a south-facing slope which is used by deer during the day in winter to maximize exposure to solar radiation.

D.B.H.: Diameter at breast height; a measurement used to give the relative size of a tree.

DEADFALLS: Dead trees which have fallen down.

DEN: The lair or hiding place of an animal.

DETRITUS: In the ecological sense, any fine particulate debris of organic or inorganic origin.

DIELDRIN: An organochlorine pesticide used in termite control and as a seed treatment; it is extremely persistent and may accumulate in the tissues; has been implicated in decreased egg-shell thickness in birds.

DISCRIMINANT FUNCTION ANALYSIS: This is a multivariate statistical technique for studying the extent to which different populations overlap one another or diverge from one another.

DIURNAL: Active during the day.

DIVERSITY: Variety; multiformity; quality, state, fact, or instance of being different or varied.

DIVIDE: A ridge that divides two drainage areas; watershed.

DRUMLIN: A long ridge or oval-shaped hill formed by glacial drift.

EARLY SUCCESSIONAL FOREST: The early stage in forest succession, where succession is the progressive change in composition of a community of organisms towards a largely stable climax; e.g. from initial colonization of a bare area by algae, followed by lichens, mosses, herbs and grasses, shrubs and bushes, subclimax trees, and climax forest.

ECOLOGICAL PERTURBATIANS: Ecological disturbances.

ECOLOGICAL RELEASE: Allowing certain organisms to flourish and increase after the removal of some restraining factor in the environment.

ECOLOGICALLY SENSITIVE AREAS: Those areas which are easily changed from their natural state and may require a prolonged period of time to recover or revert back to the natural, wild, undisturbed condition.

ECOLOGY: Study of the relations of animals and plants, particularly of animal and plant communities, to their surroundings, animate and inanimate.

ECOTONE: Transition or interdigitated area between two adjacent communities, as the merging zone of adjacent forest and grassland.

EDGE EFFECT: Relative amount of intermingling of habitat types in an environment; in general , the greater the admixture, the greater the ability to support large animal populations; e.g. the intermingling of small patches of cultivated fields, pastures, meadow, brush, and woodland.

EMERGENT VEGETATION: Vegetation rooted on the bottom of a pond, lake, stream, etc., but having leaves, flowers and fruits growing above the water's surface.

EMIGRATION: Leaving an area or region in order to settle in another.

EROSION: Forming by wearing away gradually; as, the running water eroded a gully.

ESKER: A winding narrow ridge of sand or gravel, probably deposited by a stream flowing in or under glacial ice.

EXTIRPATE: To make extinct on a local level; e.g. to eradicate a particular species from a lake.

FAULT: In geology, a break in rock strata or veins that causes a section to become dislocated along the line of fracture.

FEEDING GUILD: An association or group of species having similar food habits i.e. seed-eating birds.

FEEDING REGIMES: A pattern of feeding involving similar food types or similar hunting locations.

FINCHES/FRINGILLIDAE: Largest bird family in the Order Passeriformes; includes cardinals, grosbeaks, finches, sparrows, towhees, juncos, buntings; bill short, stout, adapted for seed-eating.

FINGERLING TAGS: Small identification tags used to mark small fish.

FLEDGE: To acquire flight feathers; to care for an immature bird until it is able to fly.

FLOATING VEGETATION: Plants rooted in the bottom of a pond, lake, or stream with some or all leaves and flowers floating on the water's surface.

FLAG: To mark with a small piece of coloured cloth or tape.

FLUSH: To start up from cover: said of birds.

FLYCATCHERS/TYRANNIDAE: Large family of passerine birds which includes flycatchers, pewees, kingbirds, and phoebes; feed mainly on insects.

FOOD WEB: Complex species interrelationships in any community with special reference to feeding habits; a typical food web includes plants, herbivores, carnivores, omnivores, and detritus feeders.

FOLIAGE DENSITY BOARD: A white board 2 m high and 0.33 m wide and horizontally subdivided into six equal squares; used to measure foliage density or amount of cover provided by vegetation.

FOLIAGE HEIGHT DIVERSITY: An index of the vertical foliage profile.

FORAGING: The act of searching for food.

FOREST COVER TYPE: Collectively, the vegetation, debris, and irregularities of the substrate of a particular forest type.

FUNCTIONAL HABITAT TYPE: A type of habitat important in either maintaining the normal metabolism of an animal or its behaviour; e.g. feeding habitat, nesting habitat.

FURBEARER: A mammal whose fur is of commercial value; includes mink, raccoons, beavers, muskrats, etc.

GESTATION: Period of carrying the young in the uterus, from conception to delivery, especially with reference to the length of this period.

GLACIAL-FLUVIAL: Of a glacier.

GLACIAL DRIFT: Rocks, gravel, sand, etc. carried away from one place and deposited in another by a glacier.

GRANITE: A very hard, igneous rock, usually gray or pink consisting chiefly of crystalline quartz, feldspar, and mica.

GRID MAP: A map with a grid superimposed upon it permitting one to pin-point specific areas on the map by use of coordinates.

HABITAT: The specific place where a particular plant or animal lives; usually used in a more restricted sense than environment, and refers to a smaller area; e.g. spring brook, tree top, weedy pond, and sandy beach.

HABITAT DISTURBANCE: Anything which changes the habitat from its natural state.

HABITAT GENERALIST: An organism not having very specific and restricted habitat requirements; capable of living in a variety of habitats.

HABITAT HOMOGENEITY: Similarity or uniformity of habitat.

HABITAT STEREOTYPY: Unvarying, fixed, or conventional habitat.

HABITUATE: To make used (to); accustom; familiarize usually through repeated exposure to a stimulus.

HARDWOOD FOREST: Deciduous forest.

HEPTACHLOR EPOXIDE: A break-down product of chlordane which is more toxic than its parent compound; may be used as a seed treatment; extremely persistent and accumulates in the tissues.

HISTORGRAM: A bar graph.

HOME RANGE: General area traversed during the normal daily or seasonal activities of an animal, but is not actively defended.

HUMMOCK: A low, rounded hillock or bump on the ground.

HYDROPHILIC: Having an affinity to water.

IGNEOUS ROCK: Rock formed by volcanic action or great heat.

IMMIGRATION: Coming into an area or region in order to settle there.

IMPACT: A force or shock producing a change.

INCUBATION: Induction of development in eggs by the means of heat from the parent bird which is sitting on them.

INTERSPECIFIC: Between different species.

INTERSPERSION: See EDGE EFFECT.

INTOLERANT: Referring to species which are unable to exist under certain specified conditions i.e. tree species which are unable to survive in the shade.

INTRASPECIFIC: Between members of the same species.

KAME: A hill or short high ridge of stratified glacial material.

LACUSTRINE: Of a lake; found in or on lakes.

LAKESHORE: All land susceptible to ribbon shoreline cottage development.

LINEAR ORDINATION: To order along a single line or axis.

LITTORAL ZONE: In lakes, that shallow portion of the bottom from the shoreline to the lakeward limit of rooted aquatic growth; the term is also used to include both the bottom and the water above the bottom at the depth indicated.

MACROHABITAT: The larger environment in which an organism exists, e.g. a forest, a lake.

MANAGEMENT: The act of handling, controlling or directing species to achieve desired objectives.

MARSH: A tract of low, wet, soft land often associated with the mouth of a creek or river; common plants associated with marshes include cattails and tall emergent aquatic grasses, or other monocotyledons.

MATURE DECIDUOUS FOREST: Forest consisting chiefly of fully grown trees which lose their leaves periodically such as maples, oaks, elms, beeches, etc.

MELANIC: Black soils.

MERCURY: A heavy metal which is used as a fungicide and may also be released into the environment in the effluent from pulp and paper mills; attacks the nervous system of both adult and unborn young animals causing permanent damage or death.

METASEDIMENTS: A metamorphic rock of sedimentary origins.

MICROCLIMATE: Climatic conditions as related to small organisms living on or in the ground or in a microhabitat; such conditions are often greatly different from those in the circulating air several feet above the ground.

MICROHABITAT: Small or restricted habitat, e.g. a dead animal, fallen acorn, etc.

MIDSERAL STAGE: The stage following the initial invasion of pioneer species in the process of ecological succession.

MIREX: (An organochlorine insecticide used to control the fire ant (***Solenopsis*** spp.) and in flame-retardant coatings for various materials; tends to accumulate in the yolks of eggs and may reduce survival of the young.

MONADNOCK: A single remnant of a former highland, which rises as an isolated rock mass above a plain.

MULTIVARIATE PREDICTIVE EQUATIONS: Prediction equations derived by multivariate statistical techniques.

MULTIVARIATE STATISTICS: A branch of statistics concerned with a set of n individuals each of which bears the value of p different variates; the multivariate character lies in the multiplicity of the p variates and not in the size of the set n; the variates are dependent among themselves so that we cannot split off one or more from the others and consider it by itself i.e. genetic makeup of a human being.

NEOTROPICAL MIGRANTS: Referring to birds which migrate to the Neotropics, a zoogeographic realm of the world including South America, Galapagos Islands, West Indies, and Central America as far north as central Mexico.

NESTLING: Any young bird that has not left the nest.

NEURULATION: First formation of the nervous system in an early embryo.

NEUTRAL: In chemistry, giving neither acid or alkaline reaction; having a pH of 7.0 at which point the number of hydrogen ions and hydroxyl ions are of equal concentration.

NEWTS: Salamanders with vomerine teeth in two longitudinal rows; the American species are able to float without swimming movements.

NICHE: Ecological role of a plant or animal with reference to its special place in its inanimate environment and with reference to other species associated with it.

NIGHT BEDDING AREA: An area of coniferous forest used by deer during the winter nights which provides shelter from prevailing winds and has a decreased snow depth thus minimizing energy expenditure by the deer.

NOCTURNAL: Active during the night.

OPPORTUNISTIC PREDATOR: An animal feeding on those organisms which are most readily caught or are most common.

ORGANOCHLORINES: Refers to a group of pesticides having chlorine in their chemical structure i.e. DDT; also called chlorinated hydrocarbons.

ORTHIC: Referring to a particular soil type.

PARAMETER: In mathematics, a quantity or constant whose value varies with the circumstances of its application, as the radius line of a group of concentric circles.

PASSERINE: Pertaining to perching birds in the Order Passeriformes, e.g. thrushes, warblers, sparrows, etc.

PATCHY DISTRIBUTION: Describing the distributions of organisms or habitats found in small groups or clumps which are isolated by other organisms or habitats from members of their own species or from similar habitats.

PCB's: Polychlorinated biphenyls used as impregnating compounds for capacitors and transformers, liquid sealants, plasticizers, and in fluid heat systems; have been implicated in decreased egg production and decreased hatchability in some avian species.

PELLETS: Fecal droppings of certain animals; e.g. moose, deer.

PERENNIALS: Plants which live for several growing seasons and may undergo a period of dormancy during the dry season or winter.

PERIVITELLINE MEMBRANE: The membrane around a fertilized egg.

pH: Concentration of hydrogen ions in any solution; usually expressed as the reciprocal of the logarithm of grams of hydrogen ions per liter; scale ranges from pH 0 to 14, pH 7.0 being neutral; values below pH 7.0 are acid, above pH 7.0 are alkaline.

PHYSIOGRAPHIC: Pertaining to physical geography; description of the features and phenomena of nature.

PIP: To break through the shell; said of a hatching bird.

PLUMAGE: A bird's feathers.

PODSOL: A type of relatively infertile soil found typically in forests and consisting of a thin, ash-coloured layer overlaying a brown, acid layer.

POLYNOMIAL: In algebra, an expression consisting of two or more terms i.e. $X^2 - 2XY + Y^2$.

pp'DDE: A derivative of DDT, an organochlorine pesticide used in biting insect control; has been implicated in egg-shell thinning and reduced reproductive success in some avian species.

pp'TDE: A derivative of DDT, an organochlorine pesticide used in biting insect control; has been implicated in egg-shell thinning and reduced reproductive success in some avian species.

PRECAMBRIAN ROCK: The oldest known rock.

PREDATOR: Any animal that kills and consumes another animal.

PREY SPECIES: Organisms used by others for food.

PRINCIPAL COMPONENT ANALYSIS: A branch of multivariate statistics.

PROTEROZOIC: Designating or of the geological era following the Archaeozoic and preceding the Paleozoic, characterized by the appearance of the simplest types of algae, widespread glaciation, and mountain formation.

RANGEFINDER: An instrument for determining the distance of a target or object from an observer, from a gun etc.

RAPTORS: Birds which prey upon other animals, e.g. eagles, hawks, or owls.

RECESSIONAL MORAINE: A mass of rocks, gravel, sand, etc. carried or deposited by a glacier after it has withdrawn.

RECRUITMENT: Increasing number of members of a population through production of young or immigration.

REGRESSION ANALYSIS: A statistical means of studying the variation of one quantity (dependent variable) at selected levels of another quantity (independent variable).

RELIEF: The differences in height, collectively, of land forms in any particular area.

REPTILES: Class of cold-blooded vertebrates covered with scales or scutes (includes snakes, turtles, tortoise and lizards); eggs, protected by a shell.

RIBBON SHORELINE DEVELOPMENT: Cottages built around the perimeter of a lake and all having lakeshore frontage; absence of a second tier of cottages around a lake.

RIPARIAN HABITAT: The habitat found on the shore of a lake or river.

SALAMANDERS: General term for the tailed amphibians.

SCARP: A steep slope; abrupt declivity.

SCATS: Feces or droppings, especially of mammals and carnivorous birds.

SCENT POST: An object (i.e. stump, log, rock, tree, etc.) raised above the surrounding area which some animals (i.e. mink) use by urinating or defecating on or near them to mark territorial boundaries.

SCOURING: Referring to the removal of soil and/or substrate by the rapid flow of water.

SEARCH IMAGE: The ability to "key in" on target objects or organisms when foraging; ability developed after past success.

SECONDARY SUCCESSION: Ecological succession which has been interrupted and set back by some catastrophe such as a forest fire, flood, or plowing.

SEMI-ARBOREAL: Pertaining to organisms spending some part of their lives in trees.

SHORELINE: See LAKESHORE.

SHORELINE COTTAGE DEVELOPMENT: Cottages built around the perimeter of a lake and having lake shoreline frontage.

SHORE-WALKING: Sampling technique involving thorough searches of shorelines on foot for signs of mink activity.

SIBLING: Brother or sister; one of two or more organisms born or hatched of the same parents.

SILT: Any earthy material composed of fine particles, as soil or sand, suspended in or deposited by water.

SINGING POST: An elevated object repeatedly used for perching by the male bird when singing.

SLASH: The debris or trimmings from the cutting of timber.

SMALL MAMMALS: Referring to members of the orders Insectivora (moles and shrews) and Rodentia (squirrels, mice, lemmings, voles).

SNAG: A dead tree or shrub; underwater tree stump or branch.

SOCIAL DOMINANCE: In a local population of vertebrates, the existence of a system of dominance and subordination among individuals; dependent upon such factors as strength, maturity, size, aggressiveness, sex, etc.

SPATIAL HETEROGENEITY: Differences in spatial distributions.

SPAWN: In aquatic animals, to produce or deposit eggs or sperm; to produce eggs or young; eggs of fishes and higher aquatic invertebrates.

SPILLWAY: A passageway or channel to carry off excess water, as from a reservoir.

SPOT MAP: Map on which the exact locations a particular bird is seen are marked.

STABLE POPULATION: A group of organisms of a particular species which is capable of maintaining its actual numbers, sex ratio and age classes.

STEPWISE MULTIPLE REGRESSION: A technique for establishing the best set of variables to describe a dependant variable.

SUBMERGENT VEGETATION: Plants rooted in the bottom of a pond, lake or stream with the entire plant immersed in water.

SUBSTRATE: The ground or any other solid object to which an animal may be attached, on which it moves about, or with which it is otherwise associated.

SYMPATRIC: Pertaining to two or more populations of closely related species which occupy identical or broadly overlapping geographical areas.

TALONS: Claws of a bird of prey or predatory mammal.

TERRITORIAL BOUNDARIES: The boundaries of that area which an animal defends and permits no other individual of the same species to enter.

TERRITORIAL INTERACTIONS: Interactions occurring between animals with adjacent territories, which may involve territorial defence, especially during the breeding season.

TERRITORY: In the ecological sense, a specific area over which an animal (or pair of animals) establishes jurisdiction; it is vigorously defended and no other individual of the same species is allowed to come inside its boundaries; usually established for breeding purposes.

THRUSHES/TURDIDAE: Large family of cosmopolitan passerine songbirds; includes the thrushes, robins and bluebirds.

TOLERANT: Referring to organisms able to live under a variety of different habitat conditions.

TOP CARNIVORE: A flesh-eating animal which is at the top of a food chain or food web and not fed upon by other species.

TRADITIONAL NESTING GROUND: An area which has been repeatedly used for nesting in past breeding seasons.

TRANSECT: A line, usually following a compass bearing, used to divide a study plot into smaller sections in order to sample plant or animal communities.

TRAVEL LANE: A trail made by deer which is repeatedly used throughout the winter; use of a travel lane reduces energy expenditure by the deer.

TROPHIC LINK: The link between several successive levels of nourishment in a food web; e.g. the links between plants, herbivores, and carnivores.

TROPHIC RELATIONSHIP: A relationship pertaining to nutrition or to productivity.

UNDERSTORY: The trees and shrubs found in a forest which do not reach up to the canopy.

UNGULATES: Hoofed mammals; e.g. deer, moose.

UNSPECIALIZED OPPORTUNISTIC FEEDERS: Organisms feeding upon a variety of other organisms especially those which are easily acquired.

VARIABLE: In mathematics, something which has no fixed value and may vary.

WARBLERS/PARULIDAE: Large family of passerine birds restricted to North and South America; small, active, and brightly coloured.

WINTER RANGE: General area traversed during the normal winter activities of an animal, but is not actively defended.

YARD: An area where wild deer herd together for feeding and seeking shelter during the winter.

Ministry of Municipal Affairs
Ontario